



SIXTH INTERNATIONAL CONFERENCE
ON CONCEPT MAPPING

Concept Mapping to Learn and Innovate

Proceedings of the Sixth International
Conference on Concept Mapping

Paulo R. M. Correia
Maria E. I. Malachias
Alberto J. Cañas
Joseph D. Novak
Editors



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2014**

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Proceedings of the Sixth International Conference on Concept Mapping
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Preface

Welcome to CMC 2014, the Sixth International Conference on Concept Mapping, and to Santos.

These years Brazil is the organizer of great events, including the FIFA World Cup and the Olympics, and, of course keeping it in perspective, it's the natural location for our event, the bi-annual conference on concept mapping. The easy going way of life of Brazilians and the proximity of the beach should give this year's event a particular flavor that should lead to intellectual exchange and, why not, some fun.

We have a variety of topics in the academic program, with a strong presence of Brazilian educators and researchers that shows the growth in interest and usage of concept mapping in the country. We welcome these new participants to the Cmappers community. The members of the Program Committee have had a hard time selecting the papers for the conference from a large number of submissions. And of course, the conference would not take place if it were not for all the authors that are willing to share their work with the concept mapping community.

We also welcome our keynote speakers Marcia Linn, Reinhold Steinbeck, Louis Fourie and Ian Kinchin, who together with Joseph D. Novak via videoconference and an interesting set of panels complete the Academic Program.

The Local Organization Committee has done a wonderful job helping all us on our way to Santos and making sure we enjoy our stay through the Social Program.

Finally, we thank the sponsors whose support was crucial in making the Conference a reality.

Alberto J. Cañas
CMC 2014

Preface

Knowledge has become a commodity in 21st-Century society. The current economy has abundant information as raw material and innovation as the competitive advantage. The inclusion of a country into the globalized world depends on how it relates to knowledge, i.e., how it values knowledge production and dissemination. The increasing strategic importance of the triad research science/technology/innovation (knowledge production) and education (knowledge dissemination) requires new ways of dealing with knowledge. Concept maps are a way to graphically represent knowledge structures that we have stored in our memory. They are useful for organizing our conceptual schemes, enhancing individual learning, group learning, collaborative processes and creativity. This explains the growing interest of Brazilian researchers to use the technique of concept mapping, who will benefit from the exchange with the best worldwide researchers during the CMC2014. Prof. Dr. Joseph Novak, creator of the concept maps, is the honorary chairman of the Organizing Committee and fully supports the Brazilian edition of the conference.

CMC2014 will occur in Santos/SP, through 22-25 September, and its main theme is “Concept Mapping to Learn and Innovate”. The scientific program is organized into four invited talks, three panels, twenty seven sessions for oral presentations and three poster sessions. On the whole, the discussions will address various aspects of knowledge management, considering the concept mapping technique as the preferred choice to represent knowledge and organize it visually. The goal is to establish a space for discussion including academic researchers from the international community, Brazilian researchers starting to research into this area, graduate students and professionals linked to the educational sector and other professional corporations (public, private and third sector). The realization of this international conference in Brazil and the exchange of experiences that occur during scientific activities should drive the consolidation of the local critical mass on the topic. Currently, there are Brazilian researchers working with concept mapping but in a diffused and poorly integrated way. The expectation is that this event will have a bonding effect to create a Brazilian network of researchers, increasing the quantity and quality of research conducted on the technique of concept mapping.

Paulo Correia
Chair, Program Committee CMC 2014

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ACTIVIDADES PREVIAS A LA CONSTRUCCIÓN DE MAPAS CONCEPTUALES Y COMPRENSIÓN DE LA LÓGICA CONCEPTUAL

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Resumen. La construcción de mapas conceptuales tiene muchas ventajas en el terreno de la educación y es por esta razón que su uso se ha diversificado en niveles educativos y áreas de conocimiento. La estructura proposicional que conforma los mapas conceptuales tiene un impacto importante en la estructura de pensamiento de los sujetos que los construyen y leen. Hacer énfasis en la estructura de las proposiciones y la lógica para construir proposiciones es un elemento que este equipo de trabajo considera importante en la enseñanza de la técnica del mapa conceptual. El presente escrito describe una experiencia de trabajo con estudiantes universitarios de nuevo ingreso desde una propuesta que da prioridad al desarrollo de estructura proposicional previo a la construcción de mapas conceptuales, considerando que el desarrollo de esta lógica de pensamiento permite la construcción de mapas conceptuales mejor elaborados.

Palabras Clave: mapas conceptuales, estructura proposicional, lógica conceptual

1 Introducción

Existen experiencias que describen los mapas conceptuales en diferentes áreas de conocimientos y que tienen la finalidad de mostrar las ventajas del uso de esta técnica con estudiantes de diferentes niveles y áreas de conocimiento, sin embargo, el énfasis que hacen es referente a información disciplinar sin describir de manera detallada la forma en la que se acompaña a los estudiantes en la comprensión de la estructura proposicional de los mapas conceptuales para describir relaciones significativas entre conceptos. La experiencia que presentamos tiene como finalidad reflexionar sobre los procesos de acompañamiento en el aprendizaje de la técnica de mapas conceptuales de manera que sirva de base para el desarrollo de una metodología que permita la enseñanza de la técnica del mapa conceptual mejorando la calidad de los mapas construidos por estudiantes y orientándolos a un trabajo de comprensión, análisis y reflexión de la información.

Novak menciona a lo largo de su obra que los mapas conceptuales tienen como finalidad “Representar relaciones significativas entre conceptos en forma de proposiciones” (Novak y Gowin 1988) y es precisamente esta característica la que diferencia los mapas conceptuales de otras formas de representación. En este sentido el equipo de trabajo pretende desarrollar un proceso de acompañamiento en el aprendizaje de la técnica del mapa conceptual basado en la comprensión de la lógica proposicional que sirve como base del proceso de construcción de mapas conceptuales.

Si bien es cierto que la experiencia descrita en este trabajo representa sólo un primer avance de la propuesta que se pretende desarrollar para el acompañamiento en el proceso de comprensión de la técnica del mapa conceptual, contemplamos también que marca un punto de partida para futuros trabajos de investigación “formal” que permitan realizar observación, medición, análisis y evaluación de la relevancia que tienen las actividades previas a la construcción de mapas conceptuales.

2 El aprendizaje “empírico” de la construcción de mapas conceptuales

Aun cuando existe mucha literatura con respecto a los mapas conceptuales y la forma de construcción de los mismos, a través de nuestra experiencia docente y nuestro acercamiento al trabajo de otros profesionales de la educación, hemos podido observar, que muchos de los profesores que utilizan la técnica del mapa conceptual dentro de sus clases, se encargan de describir las características que lo conforman (en el mejor de los casos, dado que existen otros en los que los docentes dan por hecho que los estudiantes saben la forma correcta de construir mapas conceptuales) para después proceder de manera inmediata a la solicitud de elaboración de un mapa conceptual sobre el tema que se está estudiando, y posteriormente realizar las revisiones correspondientes con comentarios que le permitan al estudiante generar una mejor versión en ese u otro ejercicio. Consideramos que la estrategia “ensayo y error” utilizada por los profesores que hemos observado para la enseñanza de la técnica del mapa conceptual no es la más adecuada para el proceso de aprendizaje que se pretende desarrollar.

En Aprendiendo a aprender (Novak y Gowion, 1988), Novak realiza algunas sugerencias de *actividades previas a la elaboración de mapas conceptuales*, así como *actividades de elaboración de mapas conceptuales* basadas en la interpretación de textos. Es importante hacer esta reflexión dado que derivado de las prácticas cotidianas y de la “simplificación” de los procesos de enseñanza es posible caer en la práctica no tan adecuada de solicitar a los estudiantes la elaboración de mapas desde el primer momento, sin realizar algunas actividades previas que les permitan identificar lo que hemos denominado la “*lógica conceptual* del mapa conceptual”.

Algunas de las deficiencias que se han observado dentro de los mapas desarrollados por estudiantes con los que no se realizan actividades previas son: la falta de identificación de conceptos, la confusión de conceptos con palabras de enlace, la falta de estructuras proposicional, a falta de jerarquía, escritura de renglones o párrafos completos en los recuadros de conceptos o espacios para palabras de enlace. Estas observaciones nos han hecho suponer que las prácticas de “ensayo y error” derivadas de la simple explicación de los elementos que conforman el mapa conceptual, pueden provocar en los estudiantes dos cosas: 1) una inversión de tiempo mayor, así como un proceso más largo para la comprensión de la *lógica conceptual* del mapa conceptual 2) la no comprensión de esta lógica y por ende deficiencias en sus ejercicios de construcción de mapa, convirtiendo la técnica en un ejercicio carente de sentido más que en una ayuda en sus procesos de aprendizaje.

Realizando algunas observaciones en mapas conceptuales construidos por estudiantes de nivel superior, notamos que muchos de los errores que se presentan tienen que ver con la falta de diferenciación de los conceptos y las frases o palabras de enlace, así como la falta de una estructura proposicional adecuada en sus “relaciones conceptuales”.

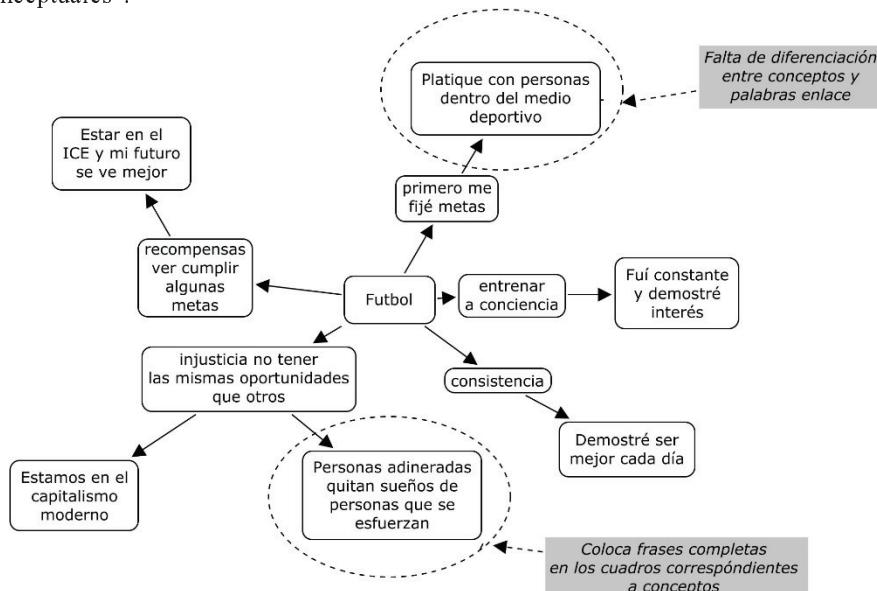


Figura 1. Ejemplo de mapa conceptual elaborado por un estudiante de nuevo ingreso al Instituto de Ciencias de la Educación UAEM. Se observa la falta de estructura proposicional y jerarquía.

Para resolver este problema se retomaron las actividades previas a la elaboración de mapas conceptuales propuestas por Novak. Haciendo una reinterpretación de las mismas obtuvimos un listado de actividades genéricas implícitas en los ejercicios que propone Novak.: 1) la reflexión sobre los conceptos 2) Identificación de conceptos 3) Diferenciación entre concepto y etiqueta lingüística 4) Diferenciación entre palabras que refieren a conceptos y palabras que no lo hacen 5) Elaboración de proposiciones (concepto- frase de enlace-concepto) 6) Identificación de conceptos en textos 7)Identificación de jerarquía conceptual. Consideramos que este tipo de actividades ayudan al estudiante a construir lo que nosotros llamamos la *lógica conceptual* del mapa conceptual que es indispensable para el desarrollo de mapas conceptuales con características mejor definidas.

Con base en estas observaciones es que nos hemos planteado el reto de desarrollar una propuesta para orientar a nuestros profesores y estudiantes en el proceso de aprendizaje de la construcción de mapas conceptuales.

3 La propuesta

Derivado de esta experiencia nos dimos a la tarea de desarrollar una propuesta que nos permitiera poner en práctica actividades que ayuden a los estudiantes en su proceso de aprendizaje de la técnica del mapa conceptual. La oportunidad perfecta se presentó cuando fuimos invitados a colaborar en el curso inductivo para estudiantes de nuevo ingreso del Instituto de Ciencias de la Educación de la Universidad autónoma del Estado de Morelos, en el año 2011, fecha en que se diseñó el taller “Organizadores Visuales y Representación del Conocimiento” dirigido a estudiantes de nuevo ingreso con la finalidad de guiarlos en el aprendizaje de técnicas de representación que les sean útiles a lo largo de su formación, especialmente, los mapas conceptuales.

Dentro de la propuesta que se elabora para impartir un módulo se contempla el desarrollo de actividades que den prioridad en un a dos elementos importantes: 1) la diferenciación de los mapas conceptuales de otras técnicas de representación y 2) el desarrollo de la *lógica conceptual* del mapa conceptual.

2.1 Los retos planteados

Al iniciar el desarrollo del programa del módulo, contemplamos que sería necesario generar una propuesta que nos permitiera abarcar lo más posible sin perder el dinamismo dentro de los ejercicios planteados y que al mismo tiempo ayudara a los estudiantes a identificar los diferentes usos de los mapas conceptuales de una manera transversal para realizar al final una reflexión con cada grupo sin perder de vista que lo más importante era el desarrollo de la *lógica conceptual* de los mapas. La evaluación se consideró como un elemento de gran relevancia, dado que no pretendíamos generar en los estudiantes una necesidad de obtención de “calificaciones aprobatorias”, sino que, más bien la evaluación fuese considerada como un proceso de identificación de los elementos a mejorar en las nuevas versiones de sus trabajos.

Otro reto importante ha sido trabajar las concepciones erróneas que los estudiantes tienen sobre lo que es un mapa conceptual, dado que nos hemos enfrentado a casos en los que los profesores de niveles previos, (que desconocen la técnica) les han hecho creer que cualquier diagrama realizado con globos y enlaces es un mapa conceptual. Este tipo de experiencias es el que nos llevó a definir las prioridades de nuestra propuesta, las cuales ya hemos mencionado. Adicionalmente es importante contemplar que esta propuesta resulta ambiciosa considerando que el tiempo destinado al módulo comprende 10 horas distribuidas de manera irregular dentro de un curso inductivo de dos semanas.

2.2 La diferenciación de los mapas conceptuales de otras técnicas de representación

Las actividades elegidas para este módulo, han cambiado desde su primera implementación con base en las experiencias obtenidas, sin embargo, existe una constante en el proceso previo a la construcción de mapas conceptuales y durante el proceso de construcción de los mismos.

En primera instancia, tomamos como referencia su experiencia previa de construcción de mapas conceptuales, para lo cual solicitamos la elaboración un mapa conceptual que permitiera presentar algún tema de su interés y dominio a sus compañeros como parte de su presentación al grupo. Esta actividad nos permite obtener información sobre los conocimientos previos de los estudiantes con respecto a la técnica del mapa conceptual e identificamos que muchos de ellos realizan diagramas que no poseen las características de un mapa conceptual (Véase Aguilar 2006), sin embargo esto no es atribuible a ellos sino a su formación previa en este tipo de técnicas.

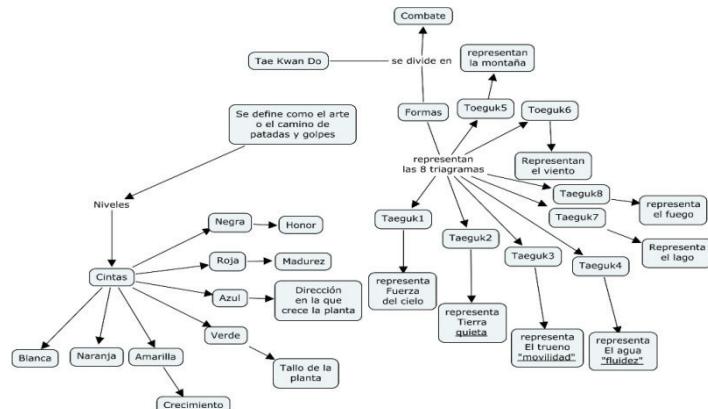


Figura 2. Este es un ejemplo de lo mapa inicial de los estudiantes

Una vez que los estudiantes han realizado sus presentaciones, se realiza una ronda de exposiciones que nos permiten reflexionar sobre las características de otras técnicas de organización visual de manera tal que pueden identificar si el ejercicio que realizaron previamente para su presentación es realmente un mapa conceptual o es más bien alguna otra técnica. Esta reflexión nos ha permitido reducir las concepciones erróneas que existen acerca de las características del mapa conceptual entre los estudiantes.

2.3 *El desarrollo de la lógica conceptual del mapa conceptual*

Para que nuestra propuesta cuente con los elementos que nos hemos planteado, integramos una serie de actividades que nos permite trabajar con los estudiantes en las habilidades previas a la construcción de mapas conceptuales. Recurriendo a las actividades propuestas por Novak, se realizan reflexiones sobre la naturaleza de los conceptos; listados de conceptos; ejemplos de palabras que son y palabras que no son conceptos; ejercicios de identificación de conceptos en textos seleccionados; y elaboración de proposiciones y lo que hemos denominado *proposiciones inversas* (que no es más que las proposiciones con los mismos conceptos pero con orden invertido).

Estos ejercicios se acompañan de un proceso de evaluación que incluye listas de cotejo, rúbricas y matrices de valoración para la autoevaluación, la coevaluación y la heteroevaluación, retomando el precepto de generar observaciones que lleven a la mejora de los trabajos realizados por los estudiantes y no a la obtención de una simple calificación numérica. Para lo cual se solicita tanto a estudiantes como a docentes una evaluación de carácter cualitativo en todos los ejercicios, que permita a cada estudiante obtener observaciones y sugerencias para mejorar su trabajo e identificar si existe un error recurrente en el cual necesite trabajar con mayor énfasis o que implique la necesidad de un acompañamiento personalizado.

4 **Las proposiciones inversas**

Una de las actividades que hemos implementado para apoyar el desarrollo de la lógica del mapa conceptual es la generación de proposiciones inversas en el orden de los conceptos. Es importante aclarar que la actividad de las *proposiciones inversas* es posterior a las reflexiones acerca de lo que es y lo que no es un concepto, las frases o palabras de enlace, así como a ejercicios de construcción de proposiciones.

El ejercicio consiste en que los estudiantes realicen la lectura de un texto corto (una o dos cuartillas), una vez leído se les solicita que generen una pregunta de enfoque e identifiquen los conceptos que les permitirán responder adecuadamente la pregunta que se han planteado. Hecho esto los estudiantes realizan ejercicios de proposiciones entre dos conceptos. Por ejemplo: LEONES comen CARNE; NEGOCIACIÓN DE SIGNIFICADOS forma parte del PROCESO DE ASIMILACIÓN.

El siguiente paso es realizar las *proposiciones inversas*, es decir tomar las mismas parejas de conceptos e invertirlos en su orden lo cual implica el cambio en las palabras de enlace (al menos en la mayoría de las proposiciones). Este ejercicio nos ha permitido reflexionar con los estudiantes sobre la diferencia entre el aprendizaje memorístico y el aprendizaje significativo, al mismo tiempo que prepara el terreno para las prácticas de cambio de jerarquía de conceptos al realizar modificaciones en la pregunta de enfoque. El ejemplo de las proposiciones inversas, tomando nuestras proposiciones anteriores podría ser: CARNE es comida por LEONES; PROCESO DE ASIMILACIÓN requiere de NEGOCIACIÓN DE SIGNIFICADOS.

El ejercicio de generar las proposiciones inversas tiene dos momentos, un primer acercamiento mediante un ejercicio grupal guiado por el docente y un segundo momento en el que los estudiantes realizan el ejercicio de manera individual. Realizar las proposiciones inversas se convierte en un reto para los estudiantes, pero al mismo tiempo les ayuda a desarrollar relaciones conceptuales más fuertes dado que pueden expresar la misma idea de maneras diferentes. Sostenemos la hipótesis de que esta actividad contribuye a la flexibilidad en la estructura mental de los estudiantes, misma que pretendemos comprobar una vez que se desarrolle el proyecto de investigación formal.

Proposiciones		
Concepto	Palabras de enlace	Concepto
<i>los sonidos</i>	<i>se utilizan para</i>	<i>representar</i>
<i>etiquetas lingüísticas</i>	<i>son</i>	<i>palabras</i>
<i>etiquetas lingüísticas</i>	<i>son</i>	<i>signos</i>
<i>Experiencia</i>	<i>conlleva a obtener</i>	<i>significados</i>
<i>Etiqueta</i>	<i>ayuda a adquirir</i>	<i>conceptos</i>
<i>Significado</i>	<i>depende del</i>	<i>contexto</i>
<i>aprendizaje representacional</i>	<i>clase de</i>	<i>aprendizaje significativo</i>
<i>aprendizaje de conceptos</i>	<i>se produce antes que</i>	<i>aprendizaje representacional</i>
<i>mapa conceptual</i>	<i>es</i>	<i>herramienta de enseñanza</i>
<i>mapas conceptuales</i>	<i>utilizados por</i>	<i>alumno</i>
<i>mapas conceptuales</i>	<i>utilizados por</i>	<i>profesor</i>
Proposiciones inversas		
Concepto	Palabras de enlace	Concepto
<i>representar</i>	<i>a través de</i>	<i>sonidos</i>
<i>palabras</i>	<i>generan</i>	<i>etiquetas lingüísticas</i>
<i>signos</i>	<i>generan</i>	<i>etiquetas lingüísticas</i>
<i>significados</i>	<i>se obtienen a través de</i>	<i>experiencia</i>
<i>conceptos</i>	<i>se conforman por</i>	<i>etiquetas</i>
<i>contexto</i>	<i>conforma</i>	<i>significados</i>
<i>aprendizaje significativo</i>	<i>incluye</i>	<i>aprendizaje representacional</i>
<i>aprendizaje representacional</i>	<i>se presenta antes que</i>	<i>aprendizaje conceptual</i>
<i>herramienta de enseñanza</i>	<i>ejemplo</i>	<i>mapa conceptual</i>
<i>alumnos</i>	<i>utilizan</i>	<i>mapas conceptuales</i>
<i>profesor</i>	<i>utiliza</i>	<i>mapas conceptuales</i>

Figura 3. Ejemplo de ejercicio de proposiciones y proposiciones inversas realizadas por los estudiantes

5 Ejercicios de construcción de mapas conceptuales

Una vez que se han realizado los ejercicios previos a la elaboración de mapas y notamos avances en la comprensión de las estructuras proposicionales, se generan ejercicios de construcción de mapas conceptuales desde dos formas de trabajo diferentes. En un primer momento se realizan ejercicios en grupo y en equipos, lo cual nos permite reflexionar posteriormente sobre la importancia de la negociación de significados al momento de construir los conceptos que se integran a nuestra estructura cognitiva. En un segundo momento se realizan mapas conceptuales individuales que posteriormente se intercambian para realizar una coevaluación sobre la implementación de la técnica. Este segundo proceso además de servir como un parámetro para identificar si se ha comprendido la forma de hacer mapas conceptuales nos permite involucrar al estudiante en la identificación de la estructura de un mapa conceptual en el ejercicio que realizó alguien más y también nos lleva hacia algunas reflexiones sobre la función de representación de conocimiento de los mapas conceptuales.

Es importante aclarar que a diferencia de los ejercicios previos, los últimos ejercicios de construcción de mapas conceptuales son acompañados del software CmapTools, esta acción tiene la intención de centrar a los estudiantes en la *lógica conceptual* del mapa y dejar las problemáticas del uso del software hasta el momento en el que se ha dominado la técnica.

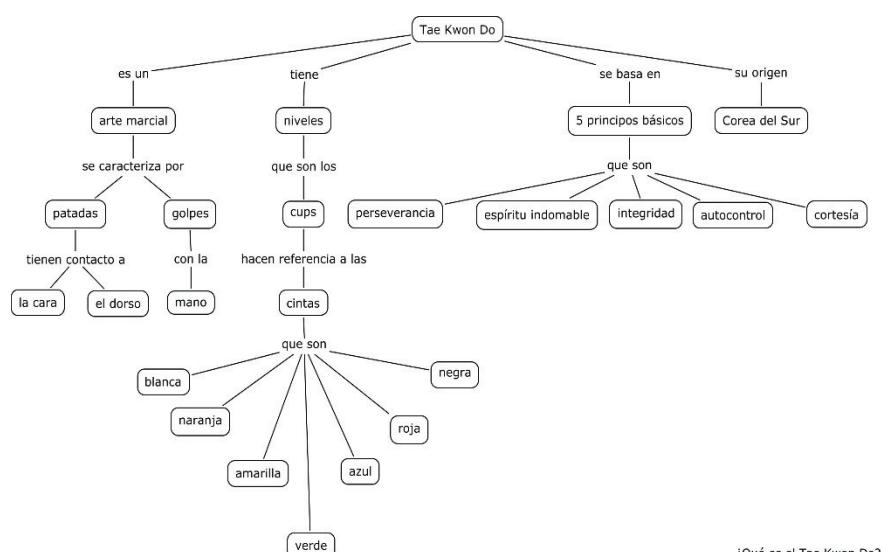


Figura 4. Ejemplo de ejercicio de mapas conceptuales finales

6 Conclusiones e implicaciones

Hasta el momento nuestros esfuerzos por generar una propuesta didáctica para la enseñanza y aprendizaje del mapa conceptual continúan en el terreno de lo empírico y en condiciones de tiempo limitadas. Si bien podríamos suponer que los resultados obtenidos tras la implementación de las actividades contempladas en el taller promueven el entendimiento de la lógica conceptual del mapa conceptual son buenos, creemos que esta conclusión puede tener un sesgo al no contar con una metodología formal para la observación y evaluación de los resultados en los mapas de los estudiantes, así como por las limitaciones de tiempo en las que se desarrolla el módulo.

Para la construcción de una metodología formal hemos considerado la posibilidad de repetir esta experiencia en mejores condiciones de tiempo y dividiendo la población en dos grupos, uno en el que se trabajen los ejercicios previos a la construcción de mapas conceptuales y otro en que no se realicen estos ejercicios, iniciando con la construcción directa de mapas conceptuales, lo cual nos permitiría generar correlaciones entre los ejercicios previos y la calidad de los mapas. Adicionalmente consideramos que será necesario extender el tiempo de los ejercicios para así como dar seguimiento de estudiantes durante cursos posteriores para determinar si han continuado con la construcción de los mapas y si éstos integran los elementos que se trabajaron durante el módulo en el que se implementó la propuesta didáctica para la enseñanza y aprendizaje del mapa conceptual.

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A METHODOLOGY TO CHANGE STUDENT-WRITTEN TEXTS INTO REPRESENTATIVE CONCEPT MAPS

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Abstract This paper will present a methodology that uses computer tools to change student-written texts into representative concept maps. This methodology is useful both in educational research and teaching because the final graphic layout obtained provides an illustrative, global and summarized perspective of the main concept relations mentioned in a set of texts. The methodology was developed based on texts collected from undergraduate Chemistry students from the Institute of Chemistry at Universidade de São Paulo (São Paulo University), Brazil, who answered a question related to the Environmental Chemistry II course. Concept maps were built considering the texts as they were written by students, original texts (1), and they were also changed for propositions (2). Concept maps built from texts with different structures were very similar when compared to one another.

Keywords: Conceptual maps, Texts, Methodological tool, Teaching, Educational research.

1 Introduction

Asking students to write texts as an answer to a question within the school environment seems to be the most conventional way of evaluating what students really know, because based on the text produced we are able to infer how much a student knows about a certain subject. When writing a text, the student brainstorms information on the subject, selects the most important pieces of information to answer the question he/she was asked, and then organizes his/her ideas to write a logical and coherent text.

Reading and reviewing students' texts are inevitable tasks, demanding considerable time of teachers, professors and researchers. And when one wants to know the most relevant ideas about a certain subject for a group of students, the task is even more difficult. Reviewing innumerable texts can be exhausting, and this makes it difficult for the teacher/professor or researcher to select and organize students' main ideas.

Based on the foregoing, this paper will present a methodology which has been developed by LAPAQ group - Chemistry Learning Research Lab, Institute of Chemistry, Universidade de São Paulo. This methodology uses computer tools to change student written-texts into concept maps and discusses the influence of text structure on the process. This paper prepared representative concept maps that provide a graphic structure with the major ideas conveyed in the texts written by a group of students.

The development of a methodological tool using written texts and providing a graphic representation of ideas is believed to be useful for showing a view of the thoughts related to the subject in question, with major concept relations, all this in an illustrative, global and summarized way. Establishing relations between concepts is fundamental for determining how much a certain subject has been understood (Moreira, 2008).

Changing texts into maps is completely justifiable because although both adequately convey information, graphics are more efficient as they allow people to build more complex meanings and to explicitly integrate knowledge by having a visual resource at hand (Veriki, 2002). Thus, this tool allows people to give a new interpretation or meaning to the contents of the text by looking to a graphic representation (Kowata, Cury, & Boeres, 2012).

The use of this tool is quite broad. It can be used in educational research and teaching. From the visual representation obtained, teachers/professors are able to infer how much knowledge an individual or group of students has. A researcher is able to make innumerable comparisons in the research process, such as conducting longitudinal studies on a certain subject. Visual representations can also broaden the access to materials during research because they show visual aspects that guide the selection and sorting out of information. In teaching, teachers/professors are able to know the relations between the concepts that are the most important ones for a group of students, and are able to organize the concepts of a class and to structure the content of a course, in addition to using the tool to evaluate learning.

2 Methodology

2.1 Data Collection

The methodology was developed based on texts collected from 16 undergraduate Environmental Chemistry students from Universidade de São Paulo, Brazil, who answered a question posed in a final test of the Environmental Chemistry II course. The question was the following: Based on the following set of concepts (Figure 2) and using these concepts (all of them, or just some of them, or words inserted thereon, or other words you may find necessary), write a paragraph to explain their relation in the context of chemical activities and their effects on the environment and human health. Students had to write a text on the subject proposed using the trigger concepts provided in Figure 2, in a way it was possible to identify in the text the presence of relations among these concepts or variations in them. These trigger concepts were pre-established based on their importance in the context of the task, with the objective of promoting students' reflection on the potential existing relations (Peixoto, 2003).

2.2 Changing texts into concept maps

Generally, the process of changing texts into concepts maps is divided into two parts, as shown in Figure 1. The first step is related to the automatic obtainment of a representative concept association matrix of the group of students, i.e., it represents the number of relations among concepts found in all texts. Hamlet® software was used to automatically obtain the association matrix. The second step is related to the semi-automatic preparation of the representative concept map using software CmapTools® and Hamlet®. The entire process is shown below.

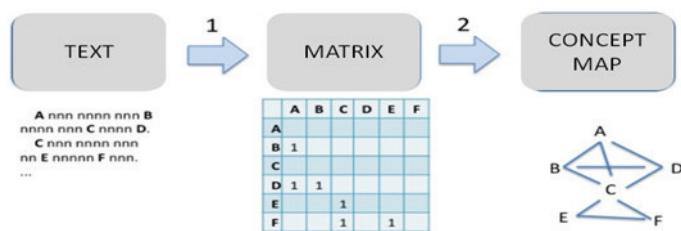


Figure 1: Flowchart of the process of changing texts into concept maps.

2.2.1 From texts to the association matrix

As a first step, all texts were digitalized as they were written and they were called original texts (1). After that, the texts were read by software Hamlet® in a single file so that a concept association matrix was created for the group of students.

Hamlet® searches for words in text files having as reference a list of words previously prepared. The software gives us the frequency in which these words appear throughout the texts, sentences or any text unit specified through an association matrix (Brier & Hopp, 2010). Here, the list of words was prepared based on the trigger concepts indicated in the question and their semantic variations.

The way the software reads texts and quantifies concept relations presented in the word list to create the association matrix is quite simple: for a certain sentence, all concepts present in this fragment and that are also present in the word list are acknowledged by the software as related concepts, that is, concepts that have some connection between them. In case of repeated concepts in one sentence, the software does not relate them to one another, but relates them to all the other concepts. Therefore, if a sentence written by one student has five concepts which are also mentioned in the word list, but one concept is repeated, the software will acknowledge eight different relations in this sentence, similarly to what is shown in Scheme 1. In this example the solvent concept is repeated.

Scheme 1: Example mentioning the relations acknowledged by Hamlet® for a sentence taken from the original text collected in the Environmental Chemistry II course.

SENTENCE	RELATIONS BETWEEN CONCEPTS ACKNOWLEDGED BY HAMLET®
“Decreased waste generation and organic solvent use can be seen in atomic efficiency calculations, which measure how much of reagent and auxiliary solvent atoms effectively participate in the final product.”	1 waste – solvent 2 waste - atomic efficiency 3 waste – reagent 4 waste – solvent 5 solvent - atomic efficiency 6 solvent – reagent 7 atomic efficiency – reagent 8 atomic efficiency - solvent

Once Hamlet® finished reading the original texts (1), the concept association matrix seen in Figure 2 was obtained. This matrix indicates the number of pair by pair concept relations found in all sentences written by the students.

Catalyzer	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
reaction conditions		7																				
Carbon dioxide			4	2																		
Atomic efficiency				11	4	2																
wastewater					2	5	1	2														
emissions						6	4	4	5	5												
stoichiometric							12	6	4	8	3	4										
Hydrogen gas								5	2	3	3	2	1	4								
Oxygen gas									5	2	3	3	2	1	4	8						
Pharmaceutical industry										3	1	0	1	1	1	2	0	0				
Chemical industry											2	0	0	0	1	2	0	0	8			
Raw materials												3	2	2	1	1	1	2	2	5	5	
Renewable raw materials													4	1	1	2	0	1	2	0	0	3
minimize														11	5	4	6	2	5	5	2	
Petrochemistry															1	0	1	2	0	2	1	
Steam pressure																7	4	3	6	4	6	
Reagents																	11	6	2	10	3	
Wastes																		3	1	3	4	
inorganic salts																		8	1	5	3	
Selectivity																			11	6	3	9
organic synthesis																			11	6	3	9
Solvents																			8	5	9	5

Figure 2: Concept association matrix obtained from the original texts (1) collected in the Environmental Chemistry II course.

Subsequently, propositions containing explicit concept relations provided in the question were taken from each text written by the students. This was done for the purposes of comparing the influence of text structure upon matrix and concept map creation. It is important to mention propositions are extracted manually and have a subjective nature because they are connected to the interpretation of the person who wrote the text. However, subjectivity is reduced with the steps described below:

1. Digitalization of all texts with their original structure preserved;
2. The pre-defined concepts mentioned in the student's text are highlighted;
3. Effective concept relations mentioned in sentences are established;
4. Finally, the proposition is structured with its respective connecting sentence or expression, preserving the original meaning.

Please find in Scheme 2 an example for better understanding the process of changing original texts (1) into propositional texts (2).

Scheme 2: Example mentioning propositions extracted from a sentence of the original text collected in the Environmental Chemistry II course.

SENTENCE	PROPOSITIONS EXTRACTED
"Decreased <u>waste</u> generation and organic <u>solvent</u> use can be seen in <u>atomic efficiency</u> calculations, which measure how much of <u>reagent</u> and auxiliary <u>solvent</u> atoms effectively participate in the final product."	<u>Atomic efficiency</u> calculations show decreased in production of <u>waste</u> . <u>Atomic efficiency</u> calculations show decreased in use of <u>solvent</u> . <u>Reagents</u> how much of its atoms have participated in the final product are shown in the calculation of <u>atomic efficiency</u> . <u>Solvents</u> how much of its atoms have participated in the final product are shown in the calculation of <u>atomic efficiency</u> .

Once all texts have been changed into propositional texts, Hamlet® reads them in a single file, creating the concept association matrix shown in Figure 3. The numbers found in the matrix correspond to the number of times a certain relation was written by the students.

Catalyzer	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
reaction conditions	2	2																				
Carbon dioxide	3	0	0																			
Atomic efficiency	4	8	1	0																		
wastewater	5	0	1	0	0																	
emissions	6	1	1	2	0	0																
stoichiometric	7	7	0	0	2	0	1															
Hydrogen gas	8	1	0	1	1	0	0	1														
Oxygen gas	9	1	0	1	1	0	0	1	0													
Pharmaceutical industry	10	4	0	0	2	2	2	1	0	0												
Chemical industry	11	2	0	0	1	1	1	0	0	0	0											
Raw materials	12	2	1	2	0	0	1	0	0	0	0	0										
Renewable raw materials	13	0	0	1	0	1	1	0	0	0	1	1	1									
minimize	14	6	0	1	0	0	0	2	0	0	0	0	0	1								
Petrochemistry	15	0	0	0	1	0	1	0	0	0	3	3	6	3	0							
Steam pressure	16	0	0	1	0	1	0	0	0	0	0	0	1	0	0	0						
Reagents	17	5	1	0	0	0	1	2	5	5	0	0	1	0	2	3	0					
Wastes	18	2	1	0	2	1	0	5	1	1	1	0	0	0	3	0	1	0				
inorganic salts	19	5	0	0	0	2	0	1	0	1	0	0	1	0	0	0	0	1	1			
Selectivity	20	9	0	0	1	0	0	2	0	0	0	0	1	0	0	0	0	0	3	0		
organic synthesis	21	1	1	0	0	0	0	0	0	1	0	1	1	0	0	0	1	1	0	1		
Solvents	22	3	2	7	2	2	0	3	0	0	0	0	1	0	2	2	5	0	2	0	0	2

Figure 3: Concept association matrix obtained from the reading of propositional texts (2).

2.2.2 From the association matrix to the representative concept map

A percentage limit representing the relations mentioned more often in the text was chosen to create the concept maps with the help of *CmapTools* (Cañas et al., 2004). In this sense, the percentage limit is established as follows: first, for a certain representative association matrix, the numeric values appearing thereon are organized in a sequence. Then, the number of times each number appears in this matrix is counted. As an example, please find below in Figure 4 how the numeric values in Figure 2 matrix are organized in a sequence and counted to create the percentage limit. The percentage limit is 25%. Thus, the concept map was created considering only those concept relations appearing more than 6 times.

Value in the matrix (1)	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
	43	40	26	29	19	12	7	8	5	4	4	1	0	0	1

Relationships established from 6 times shall be considered in the map without in 25%
--

Sum up to this point: 42 – Value nearest 49.75 (25% of the 199 relationships between
--

Figure 4: 25% percentage limit example applied to Figure 2 matrix data.

First, we obtain graphic structures showing the concepts and the existing connections according to the numeric values appearing in the matrix. Once the pair by pair relations to be shown in the concept map are defined, we searched for connecting sentences as a way to build the propositions part of the concept map with the help of Hamlet® KWIC (Key Word In Context) and human resources. Figure 5 shows the concept map created after the original texts (1) had been read and Figure 6 shows the concept map created after the propositional texts (2) had been read.

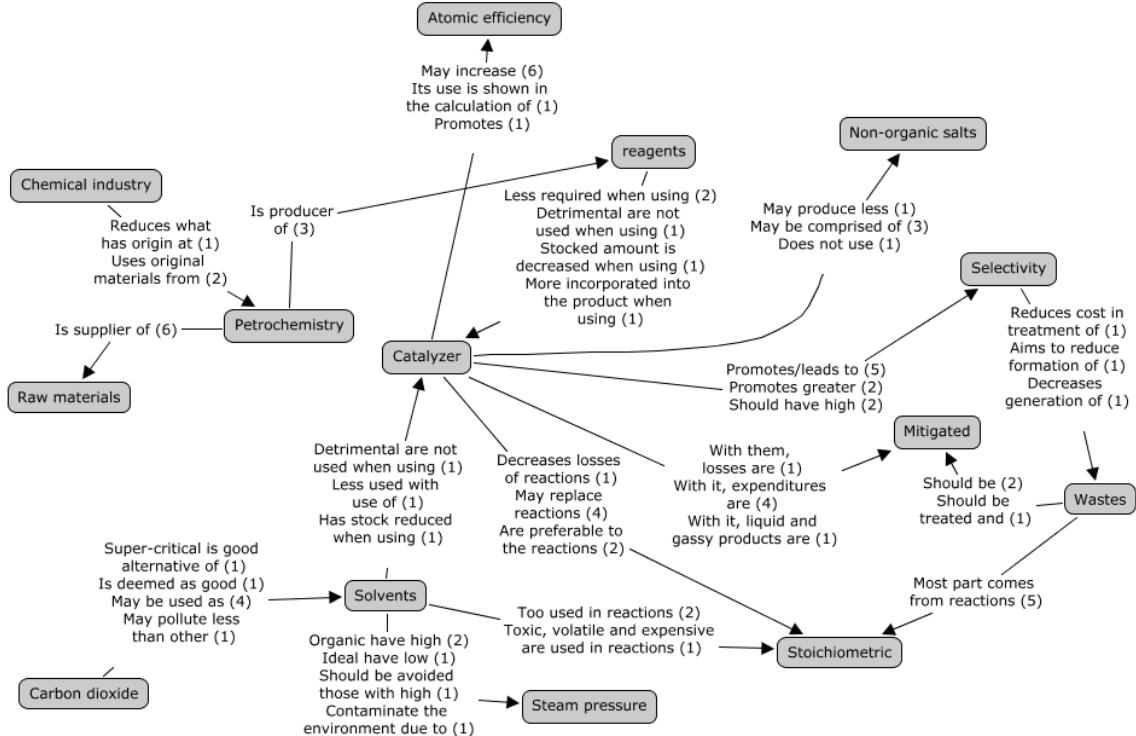


Figure 5: Concept map created from original texts (1).

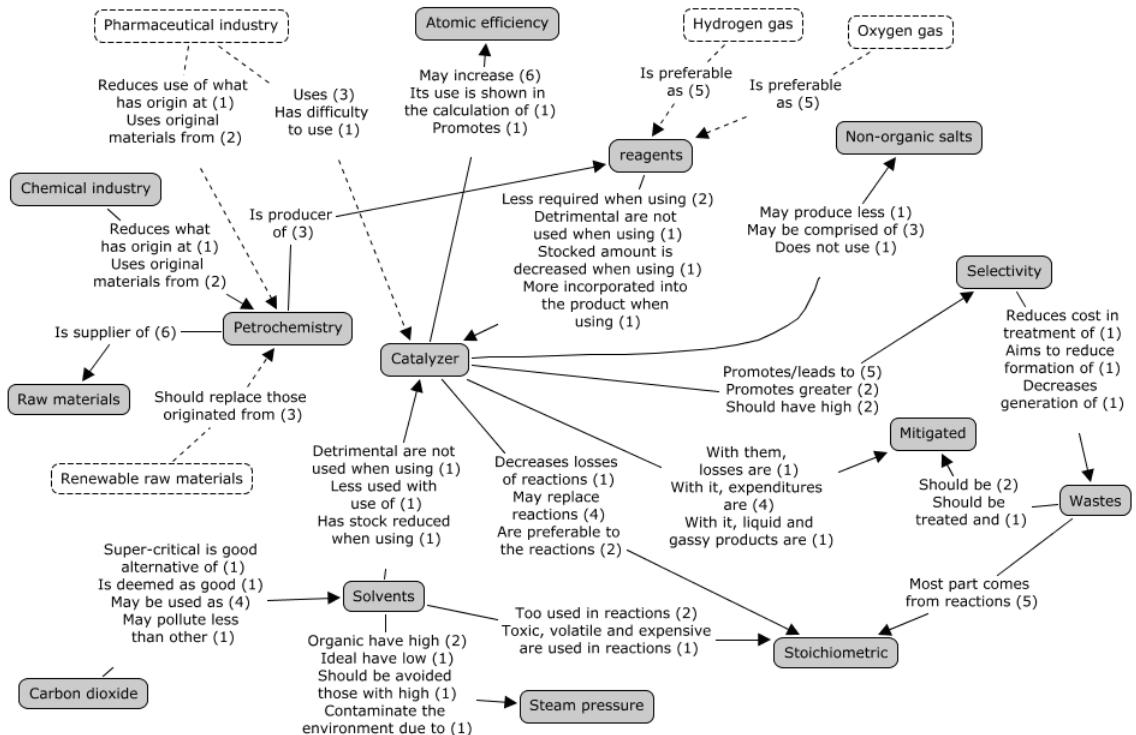


Figure 6: Concept map created from propositional texts (2).

3 Results

Original text (1) reading and propositional text (2) reading create different concept association matrixes because the number of concept relations counted is different. Scheme 3 below shows a sentence and the relations counted after the original texts and the proposition-modified texts had been read.

Scheme 3: Relations counted after original texts had been read and propositions extracted for the sentence.

SENTENCE	RELATIONSHIPS BETWEEN WORDS PRESENT IN THE ORIGINAL TEXTS (1)	RELATIONSHIPS BETWEEN WORDS PRESENT IN THE PROPOSITIONAL TEXTS (2)
"Decreased waste generation and organic solvent use can be seen in atomic efficiency calculations, which measure how much of reagent and auxiliary solvent atoms effectively participate in the final product."	waste – solvent waste - atomic efficiency waste – reagent solvent - atomic efficiency solvent – reagent atomic efficiency - reagent	waste - atomic efficiency solvent - atomic efficiency atomic efficiency - reagent

The example given shows that concept relations to be identified by Hamlet® essentially depend on the structure of text in question. Therefore, the matrix created by the software, for the purposes of quantifying concept relations, will also be different according to the structure of the text being analyzed. It is possible to say the matrix created by Hamlet® based on the analysis of students' original texts quantifies direct and indirect concepts relations. And this means that part of the relations identified coincide with those identified in the modified texts; however, others do not. For sentence 01 (Scheme 3), for example, relations between three pairs of concepts *waste - atomic efficiency*; *solvents - atomic efficiency*; and *atomic efficiency - reagents* are identified by analyzing two types of text structure. Relations between concept pairs *waste - solvents*; *waste - reagents*; and *solvents - reagents* cannot, therefore, be considered direct or propositional relations, and they have been acknowledged by Hamlet® after original text reading because the concepts mentioned were present in the same sentence.

The differences presented in the matrixes will influence the creation of concept maps. Specifically, the concept map based on propositional texts included concept relations above 3 times, with a number of concepts and connections adequate for the creation of an organized and easy-to-understand graphic structure.

Similarly, the concept map based on original texts also considered the 25% limit, but included relations above 6 times, because the original text matrix counted all relations between concepts and the values marked are higher. However, when searching for the connecting sentences between the pair of concepts for the creation of the map, it was possible to see, once again, that some concept pairs were not related in the students' texts in a propositional way, as shown in Figure 7.

In this sense, by searching for connecting sentences between concept pairs for the creation of the concept map, it was possible to see that some concept relations included in the graphic structure were not propositional. Thus, for some concept pairs, the number of times the relation has been established can be decreased when the initial graphic structure is compared to the final concept map, and some concept relations can even be excluded from the created concept map.

Therefore, out of 42 different connections between concepts included in the graphic structure initially created from the original text representative matrix (not shown here), 13 were excluded during the creation of the corresponding concept map because they were not propositional. Additionally, by searching for connecting sentences, it was possible to see that other 13 different related concept pairs actually had a propositional relation by less than 3 times. In this context, considering the purpose of this paper is converging maps created from original and modified texts as to check for the similarity between these two structures, it does make sense to create a concept map from original texts with concept relations established by less than 3 times, which are also not included in the modified text map. Thus, the original text concept map was completed with a total of 16 different connections, where the total number of relations established for each concept pair is below the number found in the graphic structure of origin concepts.

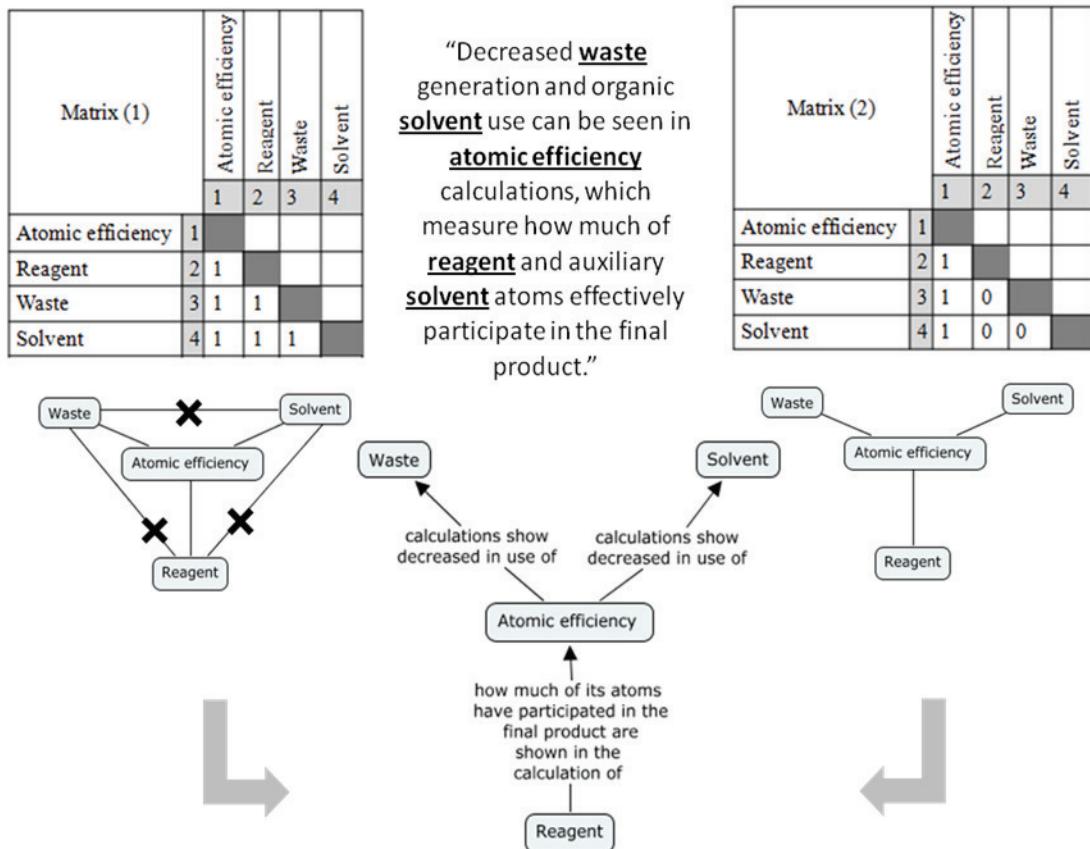


Figure 7: Illustration for the concept map creation process from two possible text structures (1 - text as written by the student; and 2 - text modified for propositions).

By comparing the two representative concept maps obtained, we have an APA - Average Percent of Agreement - (Clariana & Koul, 2008) value of 0.88. This index is used to compare similarities among concept maps. The calculation is as follows:

$$APA = \left(\frac{NL_{MC1MC2}}{NL_{MC1}} + \frac{NL_{MC1MC2}}{NL_{MC2}} \right) \cdot \frac{1}{2}$$

NL_{MC1MC2} = number of common connections between map 1 and map 2.

NL_{MC1} or NL_{MC2} = total number of connections in map 1 and map 2.

APA values near one indicate high similarity between maps. On the other hand, values near zero indicate few similar connections. The value found in the comparison indicates concept maps are 88% similar, which can also be seen in the comparison made and organized in Scheme 4. Scheme 4 shows that the number and nature of core concepts, concepts connected to three or more concepts, is different in only one concept. Regarding end concepts, those having only one connection, we have only three different concepts in the propositional text concept map.

For the subject Environmental Chemistry II the conceptual maps represented in figures 5 and 6, for example, have too much information in relation to the 5 concepts deemed as central in both graphic structures. Acknowledgment of these concepts by the students as central and important within the green chemistry context is proved to be interesting from the point of view of the understanding of the students on the subject, mainly regarding the so-called twelve green chemistry principles (Prado, 2003).

Scheme 4: Comparison among concept maps regarding concepts and existing connections.

	Concept Map – Original Texts	Concept Map – Propositional Texts
Number of concepts	14	18
Number of core concepts	5	6
Nature of core concepts	Catalyzer stoichiometric Petrochemistry Wastes Solvents	Catalyzer stoichiometric Petrochemistry Wastes Solvents <i>Reagents</i>
Number of end concepts	6	9
Nature of end concepts	Carbon dioxide Atomic efficiency Chemical industry Raw materials Steam pressure inorganic salts	Carbon dioxide Atomic efficiency Chemical industry Raw materials Steam pressure inorganic salts <i>Oxygen gas</i> <i>Hydrogen gas</i> <i>Renewable raw materials</i>
Total number of connections	16	21

4 Conclusions

The process of creating a concept map from two potential text structure matrixes is a dynamic and interactive process. The purpose is having an accurate and coherent representation of what was written by the author of the text and for this, the text and the graphic structure are constantly taken into consideration in the process. By searching connecting sentences for creating the original text concept map (1), it was possible to obtain a graphic structure which was considerably similar to the propositional text concept map (2). Additionally, the similarity between the maps suggests Hamlet® is a great software for obtaining matrixes that quantify concept relations in a text as it was written, when compared to the manual and time-demanding process of extracting propositions from a text for the creation of a matrix.

5 Acknowledgements

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A STUDY OF EFFECTIVENESS OF SCHEMATIC INTERACTIONS VISUALIZATION IN ADVANCED ENGLISH READING TEACHING - A CASE STUDY ON SOLO TAXONOMY

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Abstract. The paper aims to investigate the effectiveness of schematic interactions visualization (SIV) in enhancing individual's critical thinking in Advanced English reading teaching. SIV is a new form of interactive strategy with support of learning technology of concept maps, which consist of five interactions in three phases-before class, in class and after class. The experiment utilizes SOLO taxonomy scores to evaluate the individuals' learning outcome in four classic English articles under two different scenarios: the one with traditional learning strategy and the one with SIV learning strategy. The preliminary results reveal that the application of the multi-layered ordering SIV strategy is advantageous for individual's critical thinking and thus sets a good example for advanced English reading teaching.

Key words: schematic interactions visualization, SOLO taxonomy, critical thinking.

1 Introduction

Concept maps, a knowledge visualization tool, can be combined with recent technology to provide integration between knowledge and information visualizations (Cañas et al., 2005). With the support of concept maps, individual's implicit schematic knowledge is explicitly represented. The author has proposed concept maps-based interactive teaching model for thematic English reading based on case study. This teaching model shows that visualized implicit schematic interactions functioned as a kind of new interactive teaching strategy to enhance students' critical thinking. The theoretical framework of schematic interactions visualization in English reading teaching refers to the visual, multi-layered, orderly interactive teaching strategy between teachers and students or between students, using schema theory on the expressive form of concept maps under informational technology environment, aiming at improving the interactive effectiveness of English reading teaching and enhancing students' critical thinking (Xiang Zhang, 2014).

2 Schematic Interactions Visualization

According to schema theory, to accurately understand the main idea of the text, there are two fundamental elements: one is that possessing corresponding schemata with the text; the other is successfully activated the corresponding schemata of the text during the process of reading. When the input information can't coincide with the schema stored in individual's memory, there will be two kinds of possibilities: one is negatively refusing to accept the new information; the other is positively modifying the original schema structure to absorb "fresh" information. Schema theory advocates the necessity of interaction in reading teaching. How to, through effective interaction with learning technology, activate students' schema so as to enhance their critical thinking. This is a new problem of the application of schema theory in reading teaching.

Schema was originally created by German philosopher Kant in the 19th century, who described schema as "productive imagination" that "hides deep inside the human psyche" (Kant, 2008). Schema theory derived from Bartlett's radical experiments on retelling stories (Bartlett, 1995). According to Bartlett, by "schema" he meant "an active organization of past reactions or past experiences". Although scholars have different elaborations on the nature of schema and on how schema affects the cognition process, they do share some consensus, which paves the ground of the modern schema theory. Their common viewpoints include:

- 1) People have schemata in their mind;
- 2) People's schemata affect their cognition process;
- 3) People's schemata develop as a means of accommodating new facts;
- 4) Schema is stored in people's mind in the form of networks with concepts as nodes and the relationship between concepts as links.

Schematic interactions are kind of cognitive activities that are influenced by the individuals' implicit existed schemata. There exists various forms of schematic interactions in English reading teaching: linguistic schemata and cultural schemata interaction, language and cultural knowledge of source language and target

language schemata interaction, universal knowledge schemata and professional knowledge schemata interaction, encyclopedic schemata and language and cultural knowledge schemata interaction, contextual knowledge schemata and language and cultural knowledge schemata interaction as well as new information and existed information schemata interaction (Rong Xia, 2008). Due to the difficulties in confirming the defaults caused by implicit schematic interactions, such interactions are prone to generate schematic overlap, new schema recognition boundary ambiguity, new schema tolerance and uncertainty strategy, etc. These problems directly influenced the effective application of implicit schematic interactions in language reading teaching.

Novak (Novak, 1977) proposed that the primary elements of knowledge are concepts and relationships between concepts are propositions. Novak (Novak, 1998) defined concepts as “perceived regularities in events or objects, or records of events or objects, designated by a label.” Propositions consist of two or more concept labels connected by a linking relationship that forms a semantic unit. In summary, the teaching functions of concept maps are as follows

- 1) *Concept maps are an effective way of representing a domain of knowledge.*
- 2) *Concept maps are visual indication of the semantic network that reveals patterns, interrelationships, and interdependencies, which result in stimulating creative thinking.*
- 3) *Excellent concept map constructors can either identify new model or regularities, or explore the relationship between concepts; or capable of forming new hierarchical framework. These types of activities are high-level meaningful learning activities that can cultivate creative thinking.*
- 4) *The multi-functions of what concept maps hold make it an effective instructional tool for educators.*

Based on the above-mentioned literature review, this study seeks solution from concept maps to effectively visualize individual schematic interactions in order to further facilitate the efficiency of critical thinking training in advanced reading teaching. This study quotes the term of visualization from the field of computer science, and puts forward a new term, namely “Schematic Interactions Visualization”. Based on the instructional design of schematic interactions visualization under concept maps-based interactive teaching model for thematic English reading, the features of the framework are as follows:

A. *Visualization*

1) *Schema representation normalization.*

Thematic concept maps construction is strictly in accordance with concept maps construction procedure. Inclusive concepts are found at the highest levels, with progressively more specific, less inclusive concepts arranged below them with different shapes required by teachers. During this construction, students' implicit schema cognitive process has been converted from static state to dynamic and interactive state, which provide direct cognitive data for teachers to quickly ascertain students' recessive schemata defaults.

2) *Preservability and reviewability of cognitive process and result.*

With the support of recorder on the CampTools, students' construction process and result have been preserved as text files. These files plus students' concept maps provide teachers and students with strong cognitive evidence to review individual schemata, making it convenient for distinguishing the dividing line between the new and the old schemata knowledge, thus avoiding the repetition of schemata and leading to deepened exchange and innovation regarding comprehension.

3) *Flexibility and sharing of critical thinking.*

From an education perspective, there is a growing body of research that indicates that the use of concept maps can facilitate meaningful learning (Cañas & Novak, 2003). The freedom of carefully chosen all the triples (concept, linking phrase, concept) show how nuances of meanings have been developed, thus making students a creator to personal knowledge. Expandability of thematic concept maps develops an environment where students can collaborate and share in their knowledge construction.

B. *Multi-layered ordering*

The framework of visualization of schematic interactions in English reading teaching consists of 5 thematic concept maps interactions in 3 teaching segments.

3 SOLO taxonomy

SOLO Taxonomy is a model established by John Biggs and Kevin Collis, which aims to assess individual's learning outcome (John 2014). According to Biggs and Collis (John & Kevin 1982), individual's general cognitive structure is a purely theoretical concept, which can't be examined definitely, and it's called hypothetical cognitive structure, HCS; while individual minding structure during responding to certain questions

can be examined and it is called structure of the observed learning outcome, SOLO. SOLO Taxonomy targets to describe different levels in the quality of individual learning, which can be divided into 5 levels as follows:

- Pre-structure: individual misses any relevant points completely, such as misunderstanding the questions, lacking tested knowledge.
- Uni-structure: individual responds with only one relevant point.
- Multi-structure: individual makes use of more than one point to respond but in an inconsistent and unrelated way.
- Relational: individual can integrate all the points into a coherent framework within the scope of content in questions.
- Extended Abstract: individual generalizes the previous integrated framework into an abstract level, beyond the already-existed area of topics.

In addition to the above 5 levels, there are transitional levels between every two sequent levels.

Since its birth in 1982, SOLO has been applied extensively in different disciplines, teaching evaluation and curriculum design. Over the past 20 years, there had been more than 1000 empirical study cases based on SOLO and what's more, a quantity of doctoral thesis had applied the model (Cai 2006).

In this experiment, SOLO test were scored according to the above-mentioned five levels, showed in the following table, with the maximum score of 40 points.

Table 1: SOLO taxonomy for English reading

Levels of SOLO taxonomy	Meaning of the level	Students' possible answers	Order of evaluation	score
Pre-structure	Individual misses any relevant point completely, such as misunderstanding the questions, lacking tested knowledge.	Focus on meaningless information	A	0
Uni-structure	Individual responds with only one relevant point	Know the cultural background; or find out obvious information	B	30%
Multi-structure	Individual makes use of more than one point to respond but in an inconsistent and unrelated way	Analyze the structure; know the stylistic features and expression skills	C	50%
Relational	Individual can integrate all the points into a coherent framework within the scope of content in questions	Discriminate the content venation and logic according to the style; understand the aims and purposes of writing	D	70%
Extended Abstract	Individual generalizes the previous integrated framework into an abstract level, beyond the already-existed area of topics.	Use example in the context to support the idea; discriminate the reality through the author's thoughts, opinions and attitudes; analyze and appreciate the linguistic features	E	100%

4 Case study

4.1 Research Question

The main purpose of this study is to investigate the efficiency of schematic interactions visualization in enhancing individual's critical thinking during English reading, with the measurement of SOLO taxonomy in SOLO test as a reference in minding progress.

4.2 Research Design

4.2.1 Study Setting and Participants

The research project, named as CMAP Project, was conducted from April 2 to June 6 2014, with two-round ABAB experiments. The goal of the whole project is to evaluate the effectiveness of schematic interactions visualization as teaching strategy in English reading with experimenting on traditional assignment, such as cloze, summary, and SOLO test, while this study specifies its domain on SOLO test.

10 students from China, India, and Mauritius in Southern Medical University volunteered to participate in the project as the sample subjects for the experiment. And none of them has ever been practiced cmaps before. They are required to obtain certain level of English proficiency so as to meet the reading comprehension ability regarding of target reading materials. All of them finished the complete process of the two-round ABAB experiment. Table 2 is enclosed, as the following shows, to provide basic information about the 10 participants in the experiment.

Table 2: Information about the 10 volunteers

The volunteers	Nationality	Grade	Mother tongue
郭培莉	Chinese	3rd	Chinese
肖达辉	Chinese	3rd	Chinese
邬卓彬	Chinese	3rd	Chinese
Raj	Indian	5rd	Hindi, English
Hasibur	Indian	5rd	Hindi, English
Doonish	Mauritian	3rd	French, English
Doushant	Mauritian	3rd	French, English
Anusha	Mauritian	3rd	French, English
Zaina	Mauritian	3rd	French, English
Ziyaad	Mauritian	4rd	French, English

4.2.2 Reading Materials

The selected reading materials are the classics that have been studied by scholars many times, all from Advanced English textbooks so that depth and breadth can be guaranteed. Passage I is Face to Face with Hurricane Camille from Advanced English 1. Passage II is Marrakech from Advanced English 2. Passage III is Inaugural address from Advanced English 2. Passage IV is In favor of capital punishment from Advanced English 2.

4.2.3 Research Method and Procedures

This research adopts ABAB method with two-round experiments and utilizes SOLO taxonomy scores to evaluate the individuals' learning outcome in four classic English articles under two different scenarios: passage I and passage III use traditional learning strategy that could be regarded as method A while passage II and passage IV with schematic interactions visualization learning strategy that could be regarded as method B.

Before the experiment, a pre-meeting and gathering were arranged so that their complete unfamiliarity with concept maps construction and SOLO test were confirmed. Oval-shaped concept refers to the theme of the passage, oblong-shaped concepts refer to subordinate concepts and round-shaped concepts refer to supporting examples. And times of treatment and materials for these two different scenarios are specified the same.

As for the traditional learning strategy, participants would receive traditional learning materials through email, such as PPT involving vocabulary, extensive reading materials related with the text, teaching plan with grammar explanation, author's background cultural knowledge and text structural analysis. After traditional learning process of the passage, participants were required to finish the SOLO test of the passage with support of all those traditional learning materials.

As for schematic interactions visualization learning strategy, participants also received traditional learning materials through email, which is similar with the traditional one. And then they were required to go through 5 thematic concept maps interactions in 3 teaching segments. Let's take passage II for example.

The first segment is pre-class cooperative interaction among students. The first interaction is students' thematic concept map construction. This strategy was intended to construct visualized diagnose platform for learning.

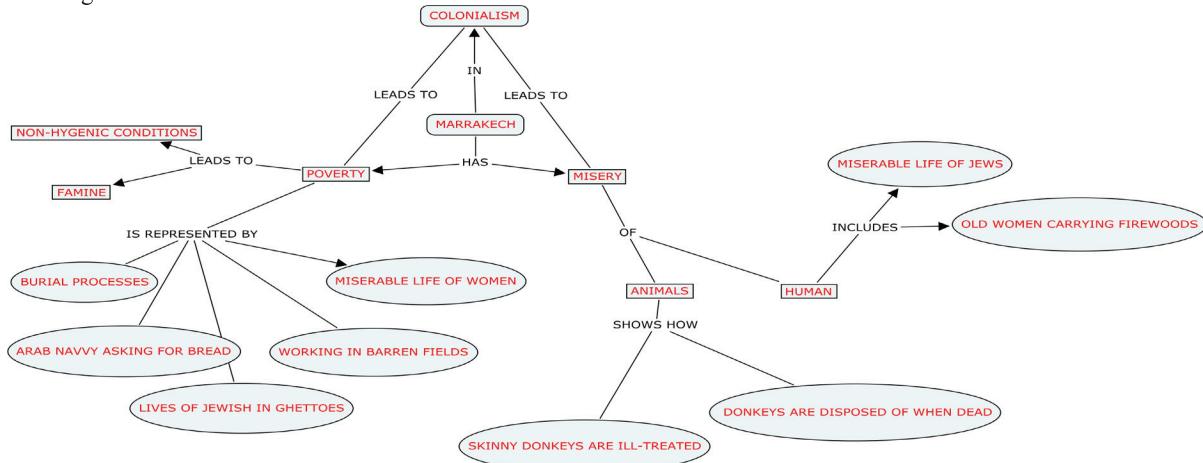


Figure 1: SIV before-class interactive activity: Student's thematic concept maps construction

The second segment is in-class collaborative interactions between teacher and students, which includes 3 interactions.

- 1) The second interaction is students' thematic concept maps presentation. The presentation adopts "one group reports, others evaluating" model, which fully mobilize students involvement in mutual learning process and conduct "peer review" process.
 - 2) The third interaction is debate on key concepts in thematic concept maps. The instructional design is based on cognitive data obtained from 1st interaction. Teachers purposely pick up concepts selected from students' thematic concept maps and leave out propositions and cross-links targeted to the teaching objectives, which aims at assessment on students' application of relevant knowledge, including linguistic knowledge, cultural knowledge and structural knowledge.

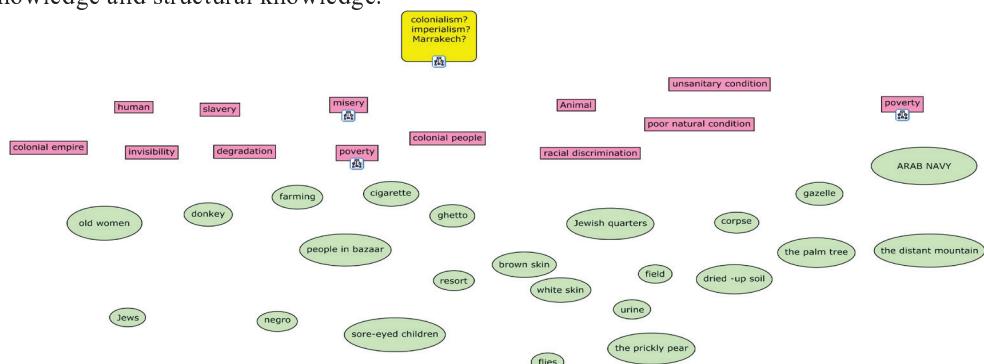


Figure 2: SIV in-class interactive activity 2: debate on key concepts in thematic concept maps

- 3) The fourth interaction is reconstruction of thematic concept maps and comparison between expert-student thematic concept maps. Students fill up the thematic concept maps discussed before to extract the potential cognitive data and then compare with expert-student thematic concept maps.

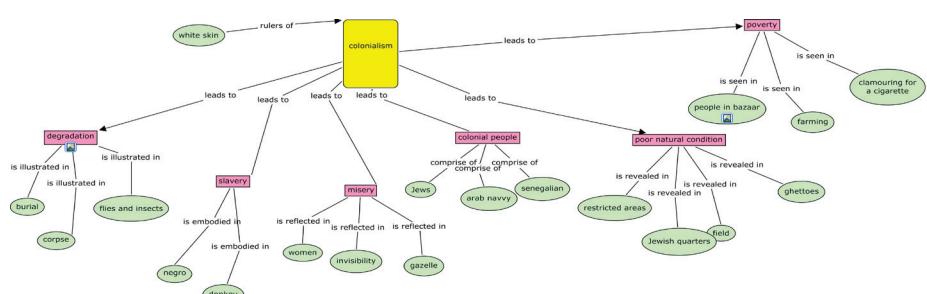


Figure 3: SJV in-class interactive activity 3: student thematic concept maps reconstruction after debate

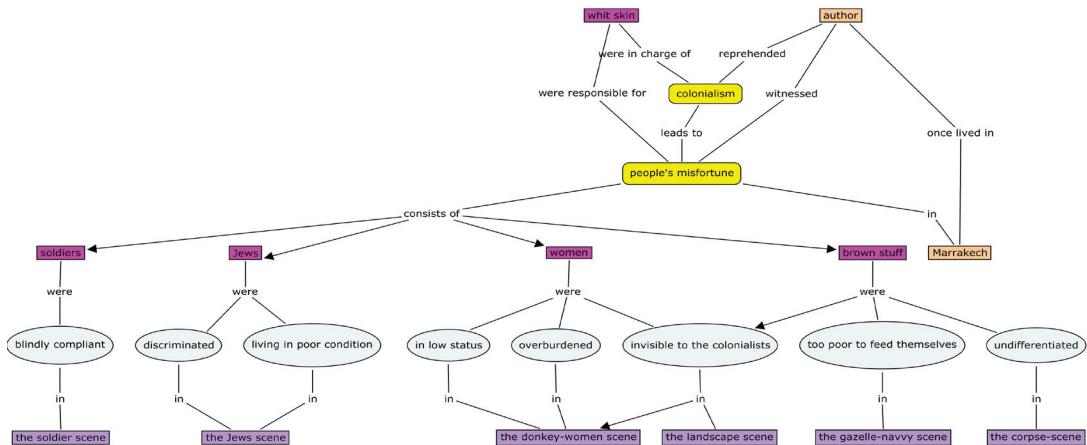


Figure 4: SIV in-class interactive activity 4: expert-student thematic concept maps comparison

The third segment is post-class students' autonomous interaction. The fifth interaction is students' extended thematic concept maps design. Students enrich their thematic concept maps with new concepts summarized and extracted from after-class extensive reading. Meanwhile, teachers preside at such kind of communication through class-blog or QQ social website for evaluating students' extended knowledge structure.

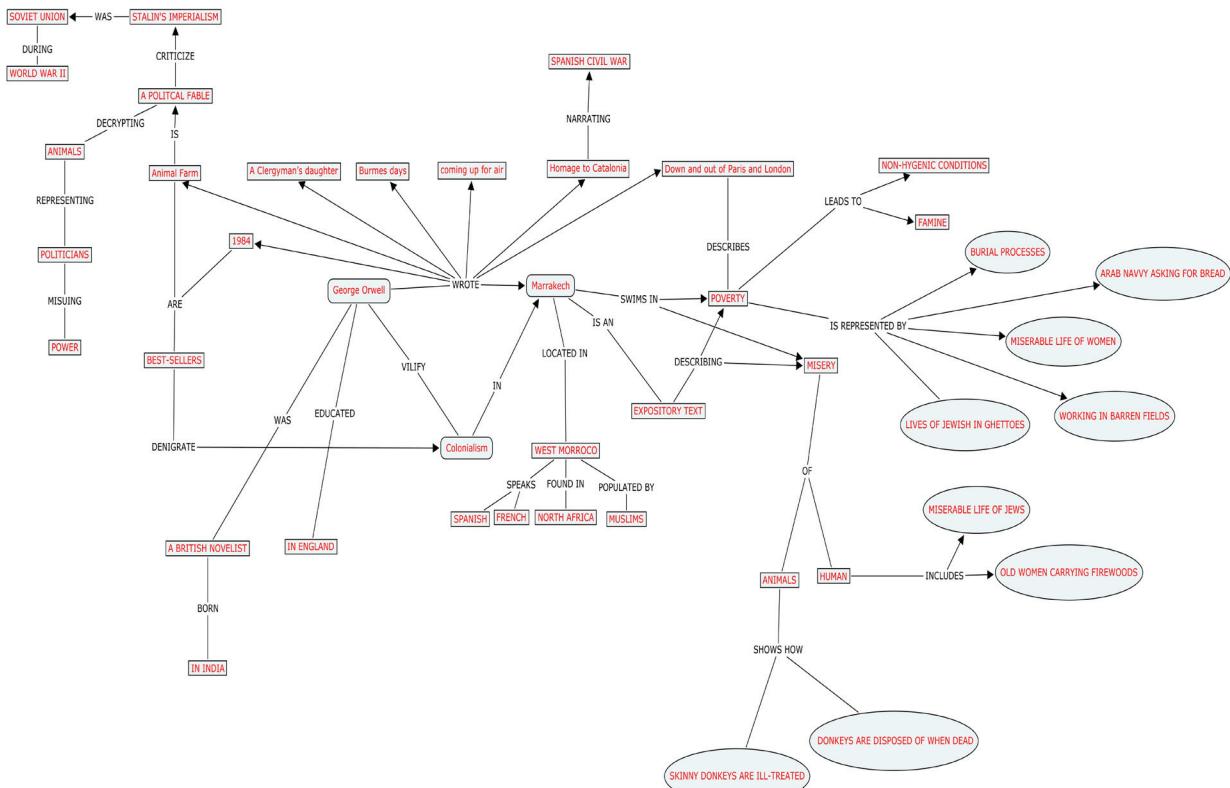


Figure 5: SIV after-class interactive activity: students' extended thematic concept maps

4.3 Results and Discussion

After two-round ABAB experiment, SOLO test scores are collected. To examine whether there is a significant difference among the individual performance under two different scenarios, repeated-measures ANOVA in SPSS is used to make data analysis as presented in Table3.

Table 3: Individual SOLO test scores of PI, PII, PIII and PIV

Name	P_I	P_II	P_III	P_IV
郭培莉	22	20	24	25
肖达辉	24	26	26	30
邬卓彬	22	26	24	25
Raj	26	22	18	35
Hasibur	18	26	18	25
Doonish	12	32	24	33
Doushant	18	38	24	26
Anusha	16	26	24	33
Zaina	12	30	28	35
Ziyaad	14	16	28	36
Mean±SD	18.40±4.971	26.20±6.215*	23.80±3.458*	30.30±4.644*#
Group Comparison	F=8.58, P=0.000			

Note: * indicates there was a significant difference compared with passage I; # indicates there was a significant difference compared with passage III

A standard deviation is utilized in order to better analyze the range of value in the changed scores. In the ranges of the improved scores, the mean score PI (M1) is 18.40, standard deviation (S1) is 4.971. Meanwhile, in the ranges of increased scores, the mean score PII (M2) is 26.20; standard deviation (S2) is 6.215. The mean score PIII (M3) is 23.80; standard deviation (S3) is 3.458. Meanwhile, in the ranges of increased scores, the mean score PIV (M4) is 30.30; standard deviation (S4) is 4.644. It's obvious to conclude from the fact ---- M2>M1, S2>S1, M4>M3, S4>S3, there's significant improvement in PII and PIV SOLO test with schematic interactions visualization learning strategy.

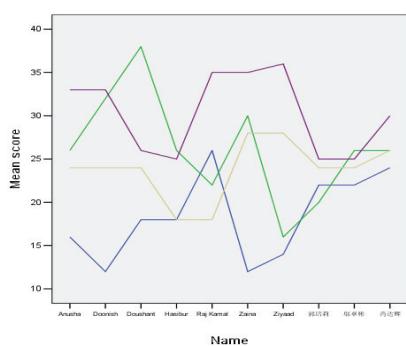


Table 4: Mean scores of Individual SOLO test scores

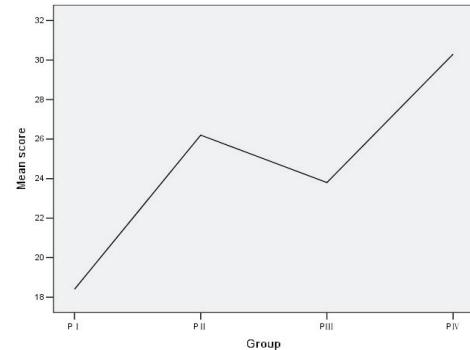


Table 5: Mean scores of PI, PII, PIII and PIV

Table 4 shows mean scores of individual solo test scores. Table 5 shows an effect of schematic interactions visualization learning strategy on the dependent variable. All four tests solo scores also show a significant difference, meaning that schematic interactions visualization learning strategy had a significant effect on students' critical thinking. Students' solo scores of passage I are the lowest one among the four test scores, and passage II solo test scores are significant improved compared with students' scores of passage I. The solo test scores of passage III are a little bit decline compared with students' scores of passage II, but not that significant. The solo test scores of passage IV are the highest one, higher than scores of passage I and passage III. However, there's no significant difference compared with passage II. That's to say, the intervention of SIV strategy would enhance students' critical thinking in Advanced English reading lesson.

5 Conclusion and Future work

In order to investigate the effectiveness of schematic interactions visualization in enhancing student's critical thinking in Advanced English reading, the case study carried out an ABAB experiment in which SOLO test scores under the traditional learning strategy and schematic interactions visualization strategy are compared. The results demonstrate that schematic interactions visualization learning strategy can improve students' critical thinking with the measurement of SOLO taxonomy in SOLO test as a reference in minding progress.

The present case study strides only a small step in investigating the effectiveness of schematic interactions visualization in improving students' critical thinking in English reading, but hopefully shall it provide a

springboard for those who are determined to continue the investigation. And more thoughts should be given to how to score students' thematic concept maps, a cognitive artifact that greatly transforms students' reading habit.

6 Acknowledgements

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AFINANDO SIGNIFICADOS MEDIANTE LA UTILIZACIÓN DE MAPAS CONCEPTUALES

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Resumen: En esta experiencia llevada a cabo en la asignatura de “Los Mapas Conceptuales en la Enseñanza” del máster en “Investigación en la Enseñanza/Aprendizaje de las Ciencias Experimentales, Sociales y Matemáticas” de la Universidad de Extremadura, se muestra la utilidad de los Mapas Conceptuales como herramienta que nos permite aclarar los significados de los conceptos en cuestión y las relaciones entre ellos hasta un punto de afinamiento que sería imposible conseguir sin la utilización de los mismos.

Palabras Clave: Conceptos, Significado, Mapa conceptual

1. Introducción

Esta experiencia surgió en una clase de la asignatura “Los Mapas Conceptuales en el Enseñanza” del máster en “Investigación en la Enseñanza/Aprendizaje de las Ciencias Experimentales, Sociales y Matemáticas” que se imparte en la Facultad de Educación de la Universidad de Extremadura (España). Este máster es realizado por alumnos que son graduados en Educación o que, siendo licenciados en otras titulaciones (Físicas, Químicas, Matemáticas, etc.), se dedican profesionalmente a la enseñanza, y ha sido distinguido con la Mención de Calidad de la ANECA (Agencia Nacional de Evaluación de la Calidad y Acreditación). Esta asignatura se llamaba inicialmente “Los Mapas Conceptuales en la Enseñanza de la Física” y era optativa y cursada únicamente por los alumnos de ciencias, pero a petición de los alumnos de otras especialidades, se le cambió el nombre y se convirtió en obligatoria y en la actualidad es seguida por todos los alumnos del master. En una clase de esta asignatura, al empezar a presentar los Mapas Conceptuales, un alumno (profesor de enseñanza secundaria en activo) intervino para manifestar que en su opinión, la utilización de dichos mapas era una cuestión de gusto personal, que podría haber personas que le viniera bien su utilización, pero que a él personalmente le venía mejor expresarse sin hacer uso de los mismos. Ante esta manifestación, el profesor de la asignatura, además de afirmar que su grupo de investigación había llevado a cabo investigaciones que habían puesto de manifiesto que la utilización de Mapas Conceptuales aportaba un aumento en la cantidad de aprendizaje conseguido (Martínez, Pérez, Suero y Pardo, 2013-I), se vio en la necesidad de mostrar a sus alumnos que con los Mapas Conceptuales se pueden conseguir objetivos que no son posibles de alcanzar sin la utilización de los mismos. Haciendo uso de su experiencia, afirmó estar dispuesto a demostrar que los Mapas Conceptuales nos permiten hilar muy fino cuando se trata de determinar el significado de los conceptos en cuestión, tan fino, que sin utilizar los mismos es imposible llegar al nivel de detalle que permite conseguir el uso de los Mapas Conceptuales.

2. Experiencia

Se partió de un Mapa Conceptual que aparece en un libro de la ESO (Enseñanza Secundaria Obligatoria) sobre Efectos y Propagación del Calor del cual se seleccionó para nuestro trabajo una parte de tan solo 4 conceptos y 3 nexos de unión entre ellos referida a los Efectos del Calor (Figura 1) y, manteniendo los mismos 4 conceptos (Calor, Incremento de Temperatura, Dilatación y Cambio de Estado) y el Calor como concepto más inclusivo, se pidió a los alumnos que propusieran mapas alternativos que les satisficiera más que el que aparecía en el libro. Es decir, que utilizaran los Mapas Conceptuales para conseguir un cambio conceptual (Martínez, Pérez, Suero y Pardo, 2013-II). Se aclaró desde el principio que nadie debería complicarse la vida considerando casos excepcionales (como puede ser la dilatación anómala del agua entre 0°C y 4°C) y que se suponía que estaba entrando calor en la sustancia considerada (no saliendo calor de la misma). Poco a poco los alumnos se fueron animando a manifestar sus diferentes puntos de vista y pasado algún tiempo la pizarra estaba llena de mapas con propuestas diferentes y la discusión había llegado a un punto que era difícil de reconducirla para mantener el orden necesario. Por esta razón, se decidió actuar de forma metódica y el profesor se comprometió a llevar a la clase del día siguiente el desarrollo de todos los mapas diferentes posibles que cumplen con las condiciones anteriormente expuestas.

Para ello, se consideraron todas las opciones que tienen de estar relacionados entre sí estos conceptos ya sea por el lugar que ocupa cada uno de ellos dentro de la estructura del mapa (los 3 conceptos en un segundo nivel

jerárquico, 2 conceptos en el segundo nivel y el otro en el tercero, uno en el segundo y los otros dos en el tercero o cada uno de los conceptos en un nivel diferente), o ya sea por ligeras variaciones en los nexos de unión que puede cambiarse ligeramente de “produce” a “puede producir” y éste último, cuando va a varios conceptos, puede tener 3 significados diferentes: “puede producir una cosa Y la otra”, “puede producir una cosa O la otra” y “puede producir una cosa Y/O la otra”.

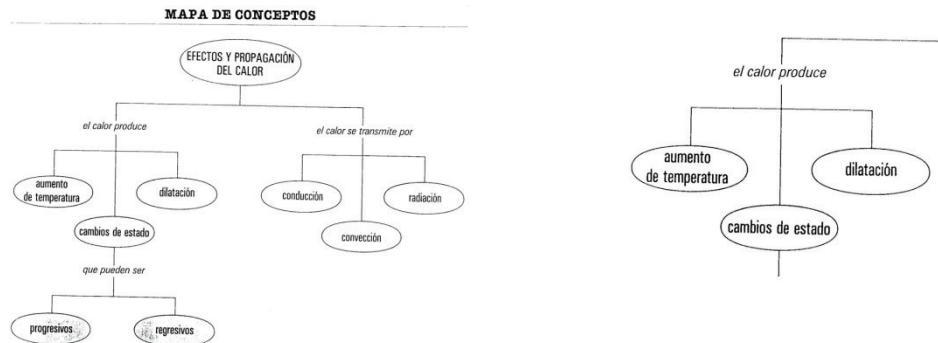


Figura 1: Mapa Conceptual inicial.

Las posibles estructuras de estos Mapas Conceptuales pueden ser (Figura 2):

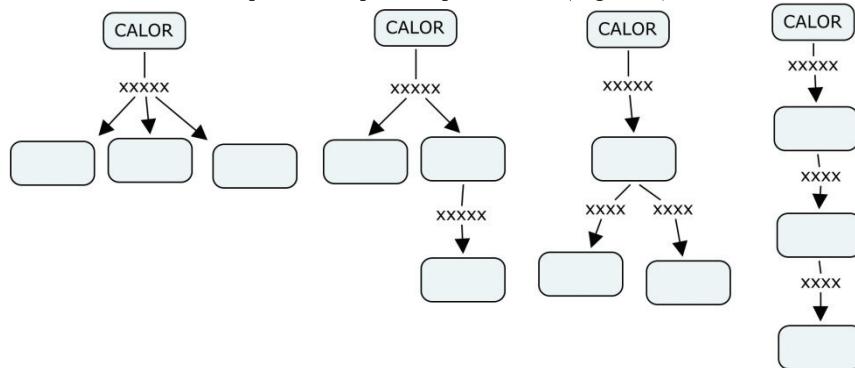


Figura 2: Posibles estructuras del Mapa.

Teniendo en cuenta todo esto salieron 58 Mapas Conceptuales diferentes que representan significados ligeramente distintos entre sí. A continuación (Figuras 3, 4, 5, 6, 7 y 8) se recogen estos 58 Mapas que pueden consultarse de manera interactiva en nuestro sitio Cmap “Universidad de Extremadura (Spain)” (visitible en: <http://grupoorion.unex.es:8001>) dentro de la carpeta “MUI en Enseñanza (UEX)/curso 2013-14” (MUI significa Master Universitario en Investigación y son los másteres cuya realización permite acceder a los estudios de doctorado y UEX significa Universidad de Extremadura). Cada uno de estos mapas lleva un Post-It en el que se describe de manera literaria el significado que expresa dicho mapa y que puede abrirse y leerse cuando se están visualizando los Mapas utilizando el software CmapTools.:

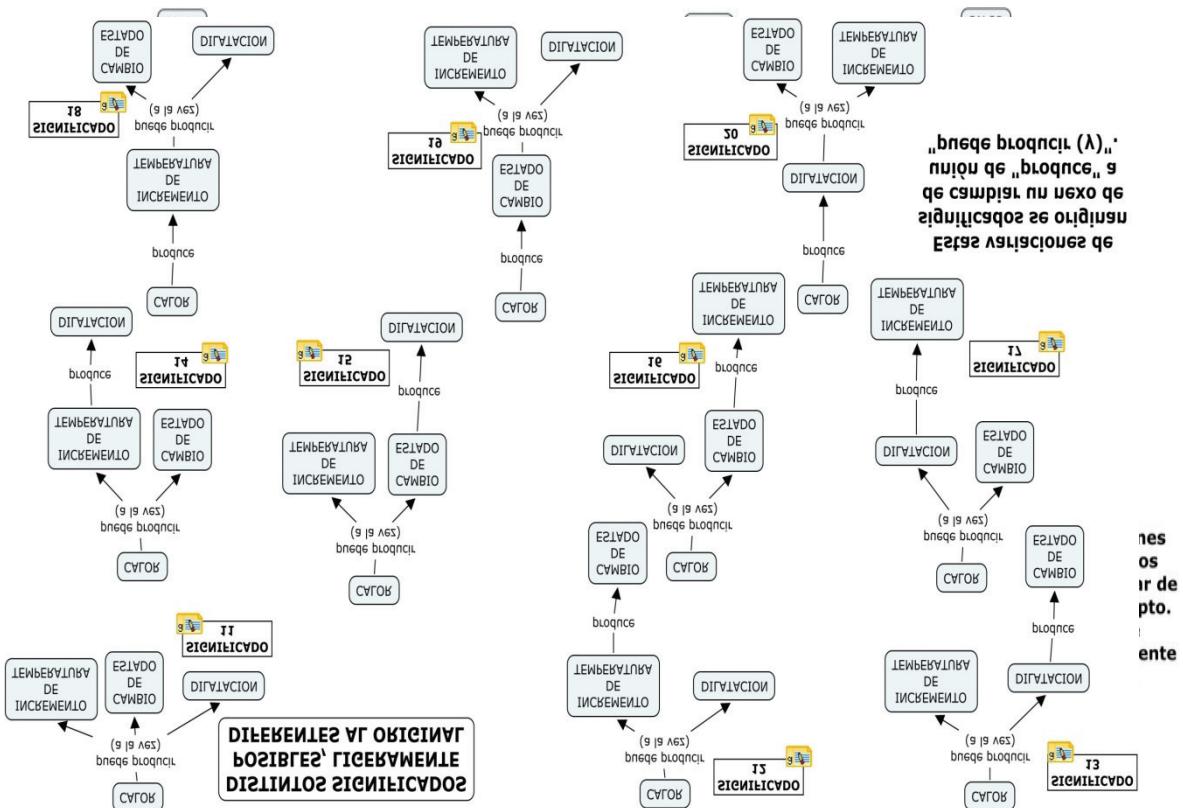


Figura 4: Diferentes Mapas Conceptuales.

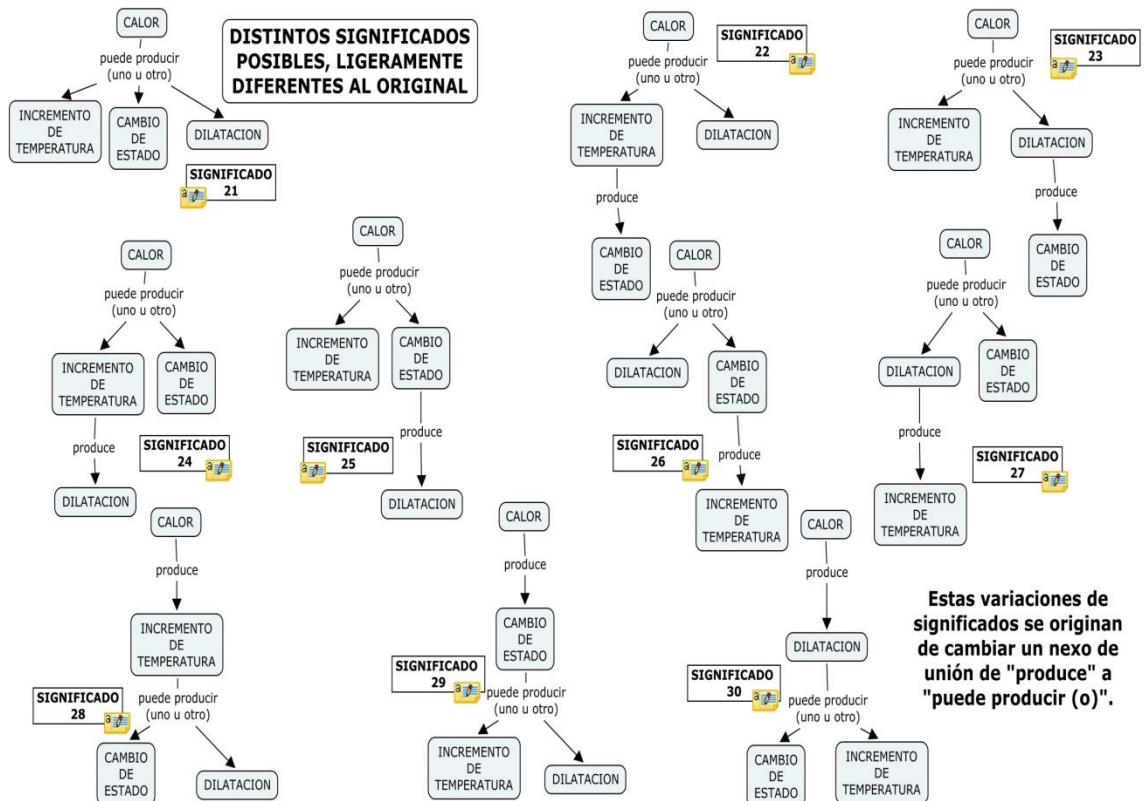


Figura 5: Diferentes Mapas Conceptuales.

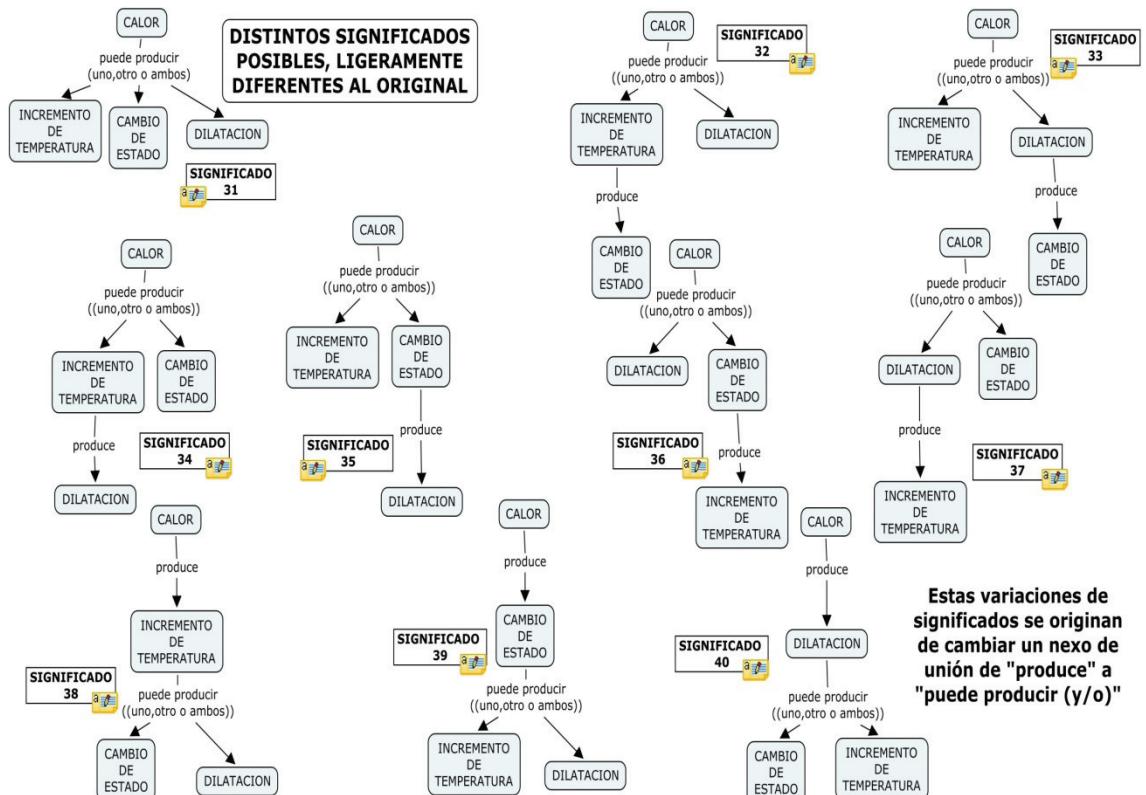


Figura 6: Diferentes Mapas Conceptuales.

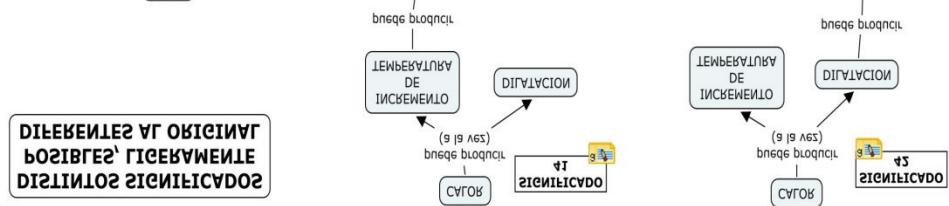


Figura 7: Diferentes Mapas Conceptuales.

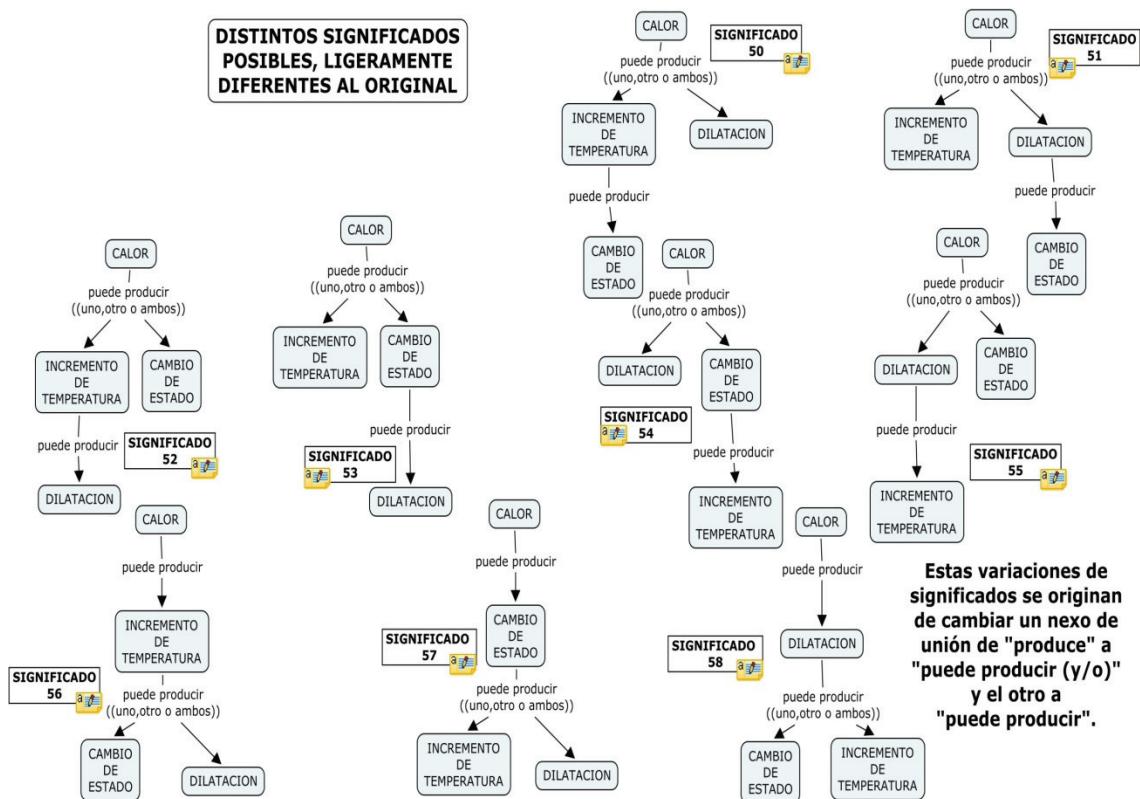


Figura 8: Diferentes Mapas Conceptuales.

3. Test elaborado

En principio, el paso siguiente debería haber sido debatir cuál de los diferentes 58 significados resultaba más explicativo para cada alumno y por qué, pero se consideró que el proceso no era operativo por complejo y que muchas de las opciones aparecidas no eran verosímiles y podían ser retiradas antes de empezar el debate. Por esta razón se decidió encargar a 5 alumnos aventajados (que voluntariamente se prestaron a ello) que hicieran una preselección de los 5 mapas que consideraran que resultaban ser los más ciertos y explicativos, para centrar en ellos la discusión definitiva. Para centrar también un poco este trabajo inicial, se decidió darle prioridad a aquellos mapas cuyos nexos de unión fuera el original “produce” y que solo se elegirían mapas con algunos de los otros nexos de unión alternativos propuestos si con ello se introducía un matiz diferenciador relevante. Cada uno de estos 5 alumnos eligió 5 mapas priorizándolos convenientemente entre sí y se seleccionaron los 5 que más veces habían sido elegidos y en lugares más preferentes y que resultaron ser los siguientes (Figura 9):

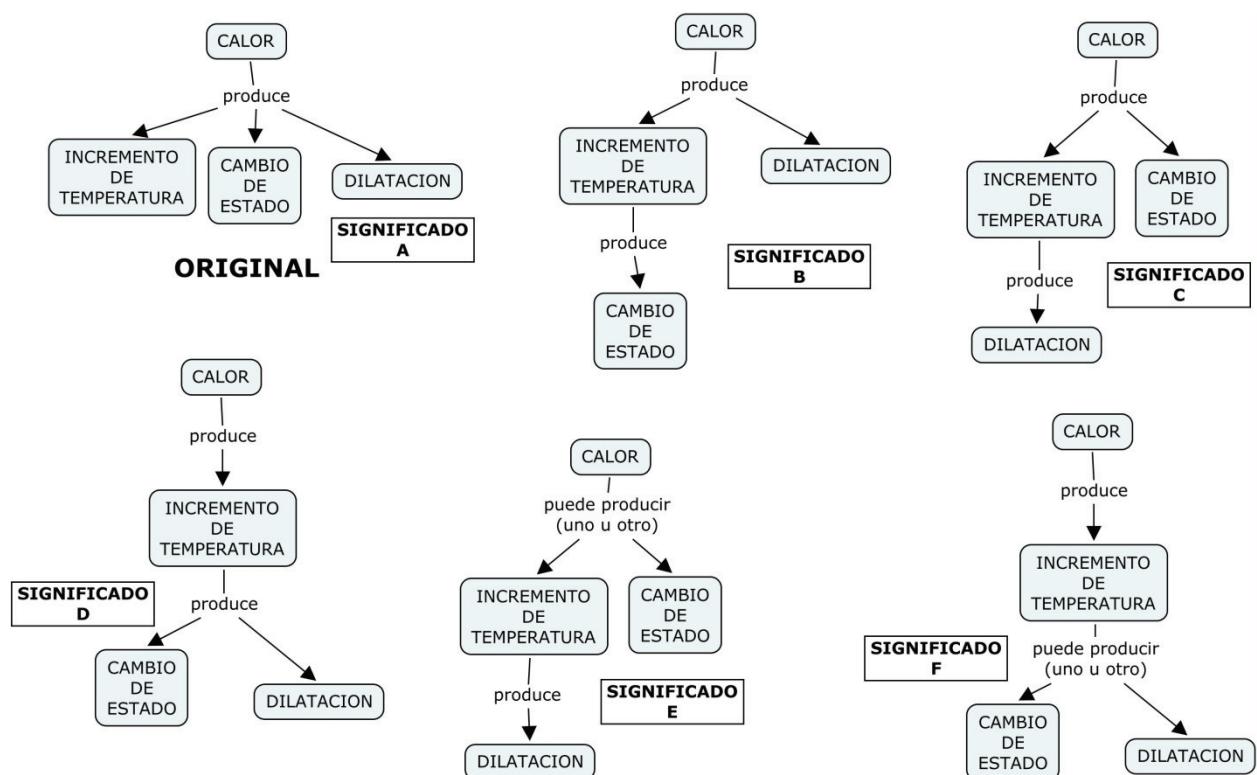


Figura 9: Mapas seleccionados para el test.

Con estos 6 mapas se elaboró un test que se pasó a un total de 74 alumnos estudiantes de las licenciaturas de Física, Química y Biología y en el que se les pedía que seleccionaran el mapa con el que estaban más de acuerdo.

4. Resultados obtenidos

En la tabla 1 y en la figura 10 se recogen los resultados obtenidos:

Tabla 1: Resultados obtenidos

OPCION	A	B	C	D	E	F
NÚMERO	7	13	12	14	12	16
%	9,5	17,6	16,2	18,9	16,2	21,6

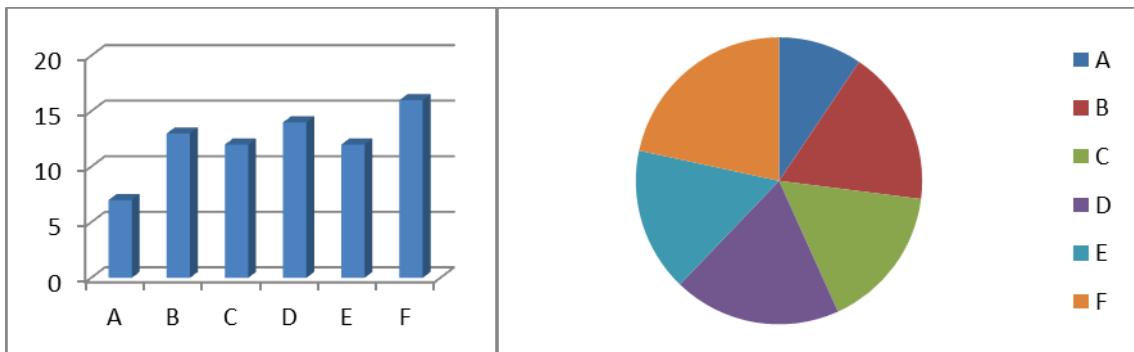


Figura 10: Gráficos de los resultados obtenidos.

Como puede comprobarse tanto en la Tabla 1 como en la Figura 10, salvo la opción original que ha sido seleccionada menos veces (quizás precisamente por serlo), las demás opciones han sido seleccionadas un número parecido de veces. Esto viene a indicar que la preselección realizada ha sido muy efectiva y todas las opciones elegidas tienen mucha verosimilitud, lo cual hace más interesante la discusión.

5. Discusión de los Resultados

Aunque el número de veces que ha sido elegida cada una de las alternativas a la propuesta original seleccionada es muy parecido, las 2 que más veces lo han sido son la F (16 veces) y la D (14 veces) y ambas son las que tienen en común que su proposición de máxima jerarquía es la misma: “cuando en una sustancia entra calor, ésta aumenta su temperatura”. Por tanto parece que ésta es la afirmación que tienen más clara los encuestados. Sin embargo, aunque muy verosímil, esta afirmación no es correcta: “no siempre que llega calor a una sustancia ésta lo emplea en aumentar su temperatura”, en ocasiones este calor es empleado para cambiar el estado de la misma manteniéndose constante su temperatura mientras dura este fenómeno. Hecha esta reflexión, quedaron desechadas las opciones F y D, precisamente las que más veces habían sido consideradas. Con respecto a la opción B, en la misma se afirma que: “el Aumento de Temperatura produce Cambio de Estado”, afirmación que dio lugar a una larga discusión de la que se concluyó que tampoco es cierta, ya que, si bien es cierto que el Aumento de Temperatura lleva al punto en el que se va a producir el Cambio de Estado, mientras se está Cambiando el Estado la Temperatura permanece constante, luego no está siendo el Aumento de Temperatura el que está produciendo dicho Cambio de Estado. Por esta razón, esta opción también fue rechazada. Por tanto quedaban solo las opciones C y E que solo se diferencian en que uno de los nexos de unión cambia del original “produce” al alternativo “puede producir” (en su sentido excluyente de uno u el otro, pero no ambos a la vez). Es claro que eligiendo esta segunda opción el mapa queda más explícito: “en algunas ocasiones la llegada de calor a una sustancia produce un Aumento de la Temperatura de la misma y en otras ocasiones lo que produce es su Cambio de Estado y cuando se produce lo primero no se produce lo segundo y viceversa”. Por tanto, la opción seleccionada después de este largo proceso resultó ser la opción E que es la que aparece a continuación (figura 11):

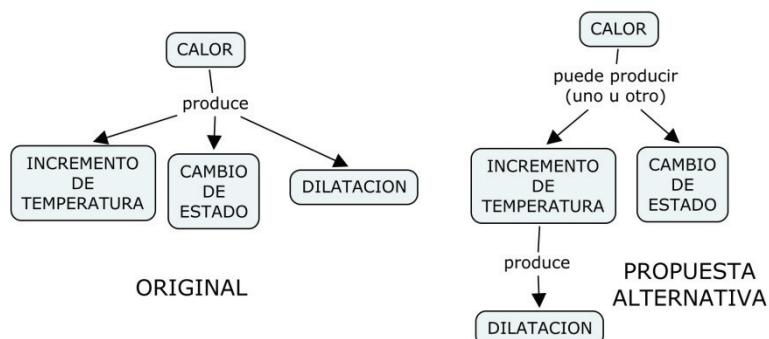


Figura 11: Mapa Original y Mapa Mejorado después de la discusión.

Puede observarse que en la nueva propuesta se establecen 3 niveles jerárquicos en lugar de los 2 que tenía la original y se mejora el nexo de unión haciéndolo más explícito y explicativo. Desde un punto de vista científico con la nueva propuesta se consiguen las siguientes mejoras conceptuales: 1^a) Se explica que la Dilatación es una consecuencia del Incremento de la Temperatura (como consecuencia del aumento de energía cinética de las partículas que supone dicho aumento de la temperatura (Tipler, 1992), que obliga a las partículas a separarse entre sí un poco más); 2^a) Se explica que la llegada de calor a una sustancia puede producir un aumento de temperatura (cuando la energía que le llega en forma de Calor es almacenada en forma de energía cinética de sus partículas) o en forma de Cambio de Estado (cuando dicha energía es almacenada en forma de energía potencial de sus partículas que se distancian unas de otras); 3^a) Se explica que ambas cosas no se producen simultáneamente; 4^a) Se aclara que el Cambio de Estado no es consecuencia del Incremento de Temperatura (bien es verdad que el Aumento de Temperatura lleva al punto de Cambio de Estado, pero mientras que el mismo se está produciendo, la Temperatura permanece constante y no puede ser la causa del mismo).

6. Conclusión

Esta experiencia sirve para poner de manifiesto que la utilización de Mapas Conceptuales permite un nivel de afinamiento conceptual que no se logra sin la utilización de los mismos. Considerando que “todo aprendizaje es respuesta a una pregunta” y que mientras no se plantee una pregunta que nos obligue a decidir cuál es nuestra respuesta a la misma, no hay verdadero aprendizaje, la realización de Mapas Conceptuales conlleva un permanente planteamiento de múltiples preguntas cuyas respuestas explícitas son necesarias para poder elaborarlos y esto supone la necesidad de aclarar nítidamente los conceptos involucrados mucho más allá de lo que se nos ocurriría aclararlos si no estuviéramos utilizando los Mapas Conceptuales. Con esta experiencia los alumnos de la asignatura quedaron convencidos de la utilidad de los Mapas Conceptuales para profundizar conceptualmente en los significados de unos conceptos que inicialmente consideraban que tenían perfectamente claros, pero que al realizar un Mapa Conceptual con los mismos se dieron cuenta de que aún le quedaban muchos matices por aclarar y muchas decisiones por tomar respecto a las respuestas a las preguntas que le surgieron al realizarlos.

7. Agradecimientos

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ANÁLISIS DE USOS DEL MAPA CONCEPTUAL EN LA INVESTIGACIÓN

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Resumen. Esta comunicación presenta un estudio sobre las funciones del mapa conceptual en la investigación. El estudio tiene como principal objetivo analizar y describir los usos y posibilidades del mapa conceptual como instrumento de investigación. Para ello se ha realizado un análisis sistemático de la documentación producida en los dos últimos Congresos Internacionales sobre Mapas Conceptuales (2010 y 2012). Los resultados arrojan 19 casos de investigaciones en las que los mapas conceptuales forman parte de su metodología y se organizan tres tipos de uso, 1) método para la reducción de datos, 2) método para la recogida de información, y/o 3) método para la guía en la observación.

Palabras Clave: mapas conceptuales, investigación, método.

1 Introducción

Los mapas conceptuales permiten la representación del conocimiento y muestra los conceptos y sus relaciones a través de una jerarquía. Esta herramienta supone la facilitación de la comprensión de las relaciones conceptuales y la estructura de conocimiento (Coffey, Hoffman, Cañas, & Ford, 2002). De esta forma, los mapas conceptuales son herramientas de gran utilidad y potencial para la enseñanza-aprendizaje. Los estudios realizados sobre mapas conceptuales muestran esta utilidad, y mayoritariamente son diseñados para conocer estas potencialidades en diferentes ámbitos, la eficacia en la evaluación, organización de la información o como herramienta de trabajo colaborativo o gestión de la información.

Sin embargo, son pocos los estudios que utilizan los mapas conceptuales como parte metodológica de su investigación. Consideramos los mapas conceptuales como un firme instrumento para ello, por este motivo, se estima necesario el conocer cuáles pueden ser las utilidades de estos en un estudio o investigación.

Para ello se han analizado y valorado las publicaciones sobre el tema realizados en los dos últimos Congresos Internacionales sobre Mapas Conceptuales y se han establecido categorías de uso de los mapas conceptuales en la investigación, presentando ejemplos de cada uno de estas categorías.

2 Marco de referencia

Los mapas conceptuales resultan una herramienta adecuada para la investigación, ya que permiten la representación de datos de investigación, de modelos de investigación y del conocimiento experto; facilitan la colaboración entre investigadores, la recogida de información y la guía en la observación. Arellano y Santoyo, (2009) exponen que a través de las proposiciones o palabras de enlace se van representando las relaciones significativas que se van entrelazando, además de presentarlo de forma visual, lo que simplifica el sistema o pregunta objeto de estudio.

Cañas et al. (2000) hacen referencia a los mapas conceptuales como herramientas para representar y publicar modelos de investigación con el fin de promover la colaboración de otros investigadores. Así, al hacer referencia a mapas creados por expertos, especifica que no solo sirven para facilitar el acceso a la información como un índice, sino que representan el conocimiento que permite la navegación sobre el modelo de conocimiento experto.

Por otra parte, el uso de esquemas en su expresión gráfica en la investigación cualitativa, para algunos autores, tal y como señala Aguilar-Tamayo y Montero-Hernández (2010), permite la representación del proceso de comprensión, utilizándose como estrategia para desarrollar códigos, conceptos y categorías y sus relaciones.

La representación del conocimiento experto como técnica de recogida de información para la investigación incluye la obtención de datos a partir de la entrevista o la observación directa de procedimientos y la posterior representación de los datos en forma de mapa conceptual. Al ser una representación explícita y manifiesta del

conocimiento, tal como afirman Novak y Gowin (1988), los mapas permiten generar la discusión e intercambiar diferentes puntos de vista entre un grupo de personas referente a las relaciones entre conceptos o denotar la falta de conexiones entre estos.

Así, una entrevista, por ejemplo, puede ser representada en forma de mapa conceptual, ya que supone una estrategia de reducción de datos, y es el propio mapa el que pasa a ser el elemento de análisis (Aguilar-Tamayo & Montero-Hernández, 2010).

Los mapas conceptuales pueden resultar una herramienta de gran potencial para realizar estudios longitudinales, ya que permiten estudiar los cambios en el conocimiento y comprensión representados, ilustrando las relaciones entre conceptos y revisar los mapas conceptuales por parte de los sujetos participantes en el estudio, formando parte así del propio proceso (O'Connor, 2012).

La utilización del software CmapTools, desarrollado por el Florida Institute of Human Machine Cognition, contribuye a que se pueda desarrollar dichas utilidades de los mapas conceptuales en la investigación, ya que apoya la colaboración y del intercambio y puede ser utilizada tanto en actividades cara a cara, como en situaciones de distancia (Novak y Cañas, 2006).

3 Análisis de los estudios que utilizan mapas conceptuales en la investigación.

El objetivo principal de este estudio es analizar y describir los usos y posibilidades del mapa conceptual como instrumento de investigación. Con este fin, y para poder establecer grupos o métodos de utilización, se han estudiado las publicaciones realizadas en los dos últimos Congresos Internacionales de Mapas Conceptuales:

1. CMC2010. Fourth International Conference on Concept Mapping. Concept Maps: Making Learning Meaningful.
2. CMC2012. Fifth International Conference on Concept Mapping. Concept Maps: theory, methodology, technology.

Se utiliza como instrumento la revisión sistemática de la documentación a través de la búsqueda de información por dichos congresos. En esta revisión se analizan los textos en base a la finalidad del estudio, la metodología y los resultados. Estos se codifican a partir del uso que se realiza del mapa conceptual. Del análisis de las publicaciones en los diferentes volúmenes de los *proceedings* de estos dos congresos, se han seleccionado 21 aportaciones entre artículos completos y pósters. De estas 21 aportaciones, 19 son estudios o investigaciones concretas y 2 análisis teóricos.

Una vez analizados se observa que pueden establecerse tres grandes grupos de uso de mapas conceptuales en la investigación a partir de los códigos utilizados.

3. Método para la reducción de datos. Se trata del grupo con mayor número de artículos ($n=16$), engloban los que utilizan el mapa conceptual como técnica de codificación y reducción de datos. De estos, podemos encontrar los que utilizan la entrevista, grupos de discusión o grupos de trabajo colaborativo, y destacan, por su posterior uso, los que se utilizan como sistema para la captura del conocimiento.
4. Método para la recogida de información. Aunque con un solo artículo, su uso en este caso, posibilita el acceso y presentación de la información a los sujetos participantes en el estudio, con el fin de poder recoger los datos necesarios para este.
5. Método para la guía en la observación. En este caso ($n=2$), la función de los mapas conceptuales es el de ser una guía para la observación en la investigación, de modo que los ítems a observar se representan en forma de mapa conceptual.

Los códigos que se han utilizado para esta categorización de la usabilidad de los mapas conceptuales en la investigación, se han representado en un mapa conceptual (Fig.1), con el fin de establecer las relaciones entre estos.

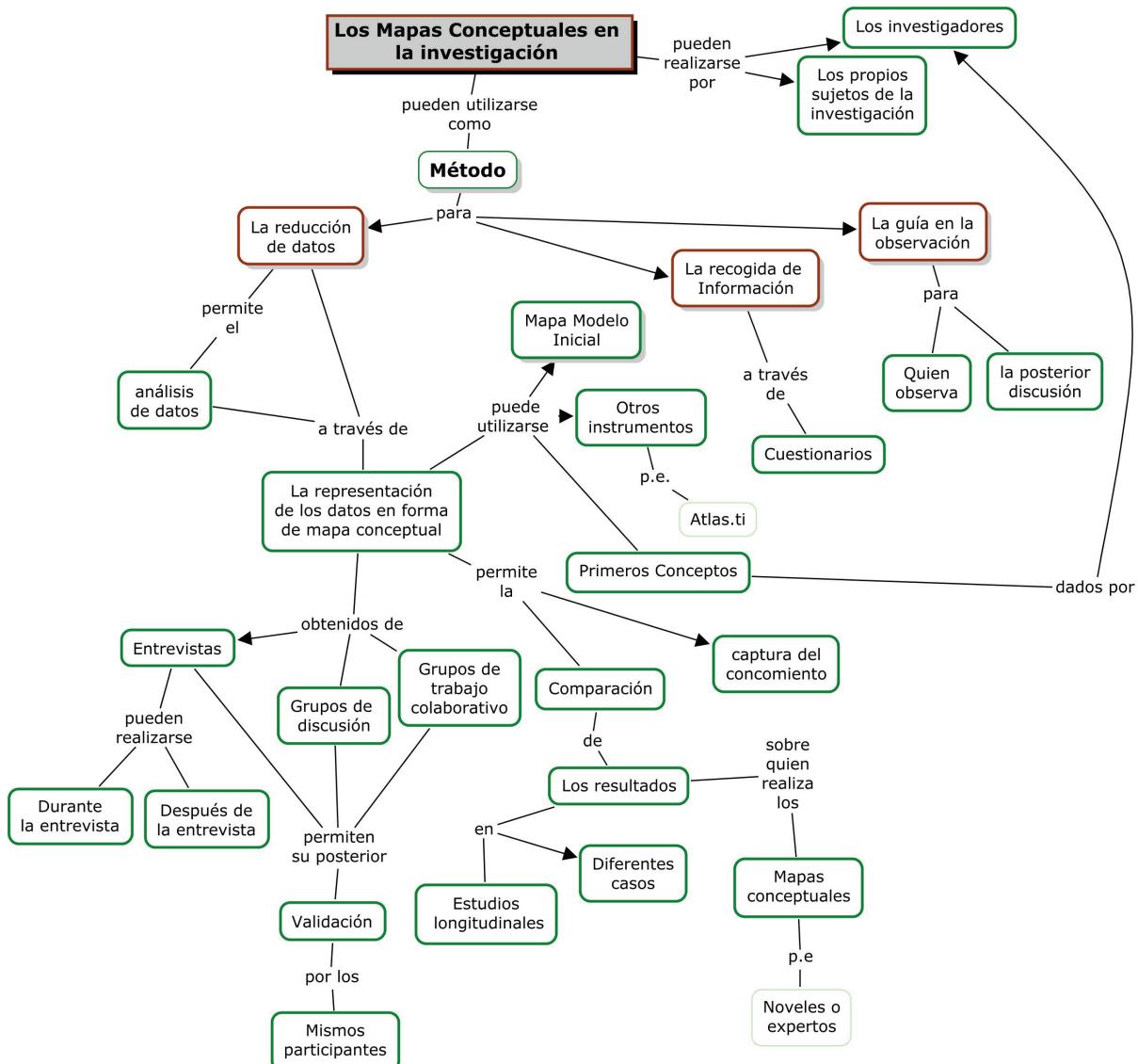


Figura 1. El mapa conceptual en la investigación

4 Resultados de usos de mapa conceptual en la investigación

Al igual que está plasmado en el mapa, hemos dividido los ejemplos en grupos de diferentes usos que puede darse al mapa conceptual en la investigación: como método para la reducción de datos, para la recogida de la información y para la guía en la observación. Aunque algunos estudios realizados se hace difícil su ubicación en un grupo u otro, debido a que muchos de los estudios reducen y analizan los datos obtenidos de los mapas conceptuales, y por tanto, se incluirían en el primer grupo, se ha considerado su clasificación por una característica diferenciadora: el uso de los mismos.

4.1 Método para la reducción de datos

Se incluyen aquí estudios que realizan la representación de los datos en forma de mapa conceptual para su análisis. Los datos de la investigación pueden ser recogidos a través de entrevistas, grupos de discusión o trabajo colaborativo.

Un ejemplo de estudio longitudinal realizado a partir de entrevistas y su posterior representación a través de mapas conceptuales es el que presentan Kandiko y Kinchin (2010, 2012a, 2012b). Desarrollan una investigación sobre la supervisión de doctorado, en la que realizan entrevistas a cuatro parejas de investigadores en formación y sus directores de tesis desde el inicio del doctorado. Estas entrevistas semi-estructuradas se realizan por separado con un intervalo de unos cuatro meses, y las transcripciones de las mismas son representadas en forma

de mapa conceptual, ya que proporcionan la estructura de los datos, lo cual, facilita el análisis dentro de los casos y en todos los casos.

San Martín, González, y Arrazola (2010) utilizan, de igual forma, los mapas conceptuales para representar las transcripciones de las entrevistas realizadas a un grupo de profesores universitarios, con el fin de identificar las buenas prácticas de estos en su docencia.

El uso de mapas conceptuales como representación de los datos obtenidos en una entrevista puede tener otra vertiente de estudio, la de quién realiza dichos mapas. Las diferencias en número de conceptos y relaciones que se encuentran en un mapa llevado a cabo por un experto o por un novel sobre una misma transcripción de entrevista son importantes, tal y como se plantea en el estudio realizado por Siirilä y Ahlberg (2012).

Otra vertiente del uso de mapas conceptuales en la investigación es la planteada por Pastor et al. (2012) quienes realizan entrevistas semi-estructuradas a un grupo de estudiantes sobre un tema en concreto. Estas entrevistas son analizadas inicialmente con el programa Atlas.ti, que establece unas categorías y redes de unión entre estas. Después, los investigadores elaboran mapas conceptuales sobre estas, lo que propicia la reflexión y trabajo colaborativo, y mejora estas primeras categorías.

En la investigación puede utilizarse un mapa conceptual previo que organice los primeros conceptos y facilite la representación de los datos. García Félix, Gargallo López, Árbalos Galcerá, & Almerich Cerveró (2012) pretenden estudiar los factores claves para el aprendizaje de los estudiantes excelentes. Utilizan el mapa conceptual como técnica de recolección de datos cualitativo, es decir, realizan entrevistas a estudiantes excelentes, cuyos datos son reducidos a través de mapas conceptuales. Con el fin de facilitar el análisis de datos y la comparación entre los mapas, realizan un mapa conceptual previo a partir del guion de las entrevistas semi-estructuradas, que servirá como punto de partida de los mapas de las entrevistas.

Weichhart & Kepler (2012) plantean y llevan a cabo una propuesta de método de investigación cualitativa para el desarrollo de ingeniería software. Este método consiste en una entrevista inicial con los expertos, los resultados de la misma se desarrollan en forma de mapa conceptual. Este mapa conceptual es validado por el experto, para que finalmente, se pueda construir el sistema de clasificación y desarrollo de software.

Por otra parte, como ejemplo de uso de mapas conceptuales para la representación de datos obtenidos en un grupo de trabajo colaborativo, Darder, Pérez, y Salinas (2012) presentan una propuesta de uso de los mapas conceptuales como herramienta de representación en un proceso en curso de construcción de un modelo de tutoría para la dirección de proyectos de investigación. Se utiliza el mapa conceptual, ya que contribuye a la representación visual de conceptos y las relaciones entre ellos. En este caso, el mapa conceptual es utilizado para representar los resultados del trabajo colaborativo de un grupo de tutores de proyectos de investigación para la construcción de un procedimiento de tutoría y posterior validación por los mismos.

Aunque no se trate de un uso propiamente dicho dentro de la investigación, consideramos que el uso de los mapas conceptuales realizado por Trujillo (2012) podría trasladarse a la investigación como método de recolección de datos de un grupo de discusión. En su caso, presenta los mapas conceptuales como una herramienta de registro de información de un taller de conversación a partir de una pregunta enfoque de investigación.

En este grupo se incluyen también aquellas investigaciones que utilizan el mapa conceptual para representar el conocimiento de un tema en concreto. Como ya se ha dicho con anterioridad, aunque se analicen los datos obtenidos de los mapas conceptuales, se prima en este grupo el uso posterior que tendrán estos mapas.

Un claro ejemplo de este tipo de uso de los mapas conceptuales en la investigación es el que presentan de Benito, Lizana, & Salinas (2012) quienes pretenden el diseño de un procedimiento que “contribuya a capturar y representar conocimiento experto en metodologías didácticas con TIC para su posterior transferencia entre pares en el entorno de formación diseñado, utilizando para ello mapas conceptuales” (p.146). Previa selección, se realizan entrevistas a docentes sobre sus prácticas docentes con TIC y se realiza un mapa conceptual durante la entrevista, con el fin de que sea validado por el propio docente. Los mapas conceptuales son utilizados como una forma de representación del conocimiento experto.

Por otra parte, puede utilizarse para conocer las diferencias entre noveles y expertos, como el caso de Simon & Levin (2012) quienes realizan un estudio donde se examinan las diferencias en las concepciones sobre conocimiento, aprendizaje y habilidades de los profesores noveles y los profesores con experiencia mediante la

construcción de mapas conceptuales durante una entrevista. En la entrevista, se presentan a estos profesores 17 conceptos extraídos de la revisión de la literatura sobre el tema, y los profesores deben agruparlos y relacionarlos según sus creencias, además de poder añadir todos los conceptos que deseen o descartar aquellos que no consideren pertinentes. Estos mapas conceptuales son analizados a partir de dos grandes consignas: la estructura del mapa y el análisis del contenido de las declaraciones verbales.

Vacca (2010) analiza los mapas conceptuales creados por docentes sobre una consigna en particular con el fin de categorizar las creencias de los mismos sobre el uso de los ordenadores en la educación. Los resultados de este estudio muestran cuatro categorías de creencias sobre el tema. El análisis de los mapas conceptuales se convierte en una importante herramienta para este estudio, ya que facilita el surgimiento de temas importantes para su investigación

Ramírez de M, Aspéé, Sanabria, & Téllez (2012) estudian los mapas conceptuales metacognitivos, entendido como “un mapa que describe la estructura conceptual del proceso de resolución de problemas y también las acciones metacognitivas que la persona toma para controlar, evaluar o corregir el mismo proceso”(p.383), para la resolución de problemas de física. Para ello, un grupo de profesores de física debe realizar un mapa conceptual sobre este proceso, incluyendo después de este, entrevistas con dichos profesores para establecer sus procesos metacognitivos y plasmarlos en el mapa, para esto último se utiliza un método dialógico-crtico. Estos mapas conceptuales pretenden servir aquí de modelo experto de resolución de problemas para su uso en la enseñanza-aprendizaje.

4.2 Método para la recogida de información

Aunque en este grupo solo se pueda presentar un estudio, sí creemos que es importante tenerlo en cuenta, ya que los mapas conceptuales son una buena herramienta para presentar información inicial, con el fin de utilizar después otro instrumento para la recolección de datos, como por ejemplo, cuestionarios, grupos de discusión, entrevistas, etc.

En este caso se utilizan los cuestionarios, Merker Moreira (2010) propone el uso de los mapas conceptuales como herramienta de presentación y representación de la información (el aprendizaje significativo y qué debe hacer un buen estudiante) para poder usar después la técnica del cuestionario. Presenta dos mapas conceptuales uno sobre el aprendizaje colaborativo y otro sobre las concepciones tradicionales sobre lo que debe hacer un buen estudiante, tanto a estudiantes como a maestros, y cada uno de ellos deberá después contestar 2 cuestionarios (uno por cada mapa conceptual).

4.3 Método para la guía en la observación

En este caso se presentan dos estudios diferenciados, el primero observa y analiza los mapas conceptuales de un grupo de alumnos y construye un proceso de análisis de mapas conceptuales y el segundo utiliza los mapas conceptuales como guía en la observación por pares.

Con el fin de identificar la evolución de las representaciones del conocimiento sobre ecología con un grupo de alumnos concreto, Salamanca y Vander (2010) utilizan los mapas conceptuales como instrumento de observación, ya que permiten visualizar las relaciones que estos estudiantes establecen entre conceptos. El punto de partida es una lista de conceptos, los estudiantes deben realizar el mapa conceptual a partir de estos, y se analizan dichos mapas a partir de tres dimensiones: el proceso de elaboración, el mapa como producto y la secuencia de lectura. Esta metodología de análisis puede ser aplicada a diferentes áreas.

Por otra parte, Miller & Kinchin (2012) efectúan un estudio de observación por pares en la docencia, utilizando los mapas conceptuales como guía para esta observación y posterior discusión. Se solicita a un grupo de docentes que realice un mapa conceptual sobre su concepción de docencia. Este mapa fue la guía para que otro de los docentes participantes en el estudio le observara durante el desempeño de una sesión de su disciplina, y posterior discusión entre ellos sobre dicho tema. Después de 3 sesiones de observación se realizó una con los investigadores y se les pidió a los docentes que modificaran sus mapas, si lo consideraban.

5 Conclusiones

La principal conclusión que se extrae del estudio es que los mapas conceptuales suponen una potente herramienta para la investigación, ya que permiten la presentación y representación de información, la captura del conocimiento experto, el análisis y reducción de datos y la guía en la observación. A continuación se presentan algunas de los principales aportes del mapa conceptual en la investigación.

1. Favorecen la categorización y reducción de datos cualitativos, representando además las relaciones entre estas categorías o conceptos de forma visual. El análisis de entrevistas, por ejemplo, a través de mapas conceptuales permite que se documente este proceso, y de esta forma el mapa conceptual se convierte también el objeto de análisis, representando la propia entrevista y la interpretación del investigador sobre esta, siendo el propio mapa el que es analizado y comparado con otras representaciones (Aguilar-Tamayo & Montero-Hernández, 2010)
2. El estudio realizado por Siirilä y Ahlberg (2012) demuestran la necesidad de que en el caso de análisis de datos y codificación de estos a través de mapas conceptuales, como por ejemplo la transcripción de una entrevista, el mapeador que realice dicha codificación sea un experto.
3. Pueden realizarse por los investigadores o por los propios sujetos de investigación. En el caso de las entrevistas, pueden hacerse también durante la propia entrevista o al finalizarla. Si los mapas conceptuales los realiza el participante en la investigación puede suponer una ventaja en cuanto a las interferencias de los investigadores. En este sentido, tal y como plantean Simon & Levin (2012) supone una fortaleza en la investigación, ya que el impacto de los investigadores en el proceso y su producto es menor que con el uso de otras herramientas como cuestionarios o entrevistas semi-estructuradas, cuyos contenidos y orden pueden influir en las respuestas
4. Favorecen la representación y presentación de información y datos extraídos de los grupos de discusión y grupos de trabajo colaborativo.
5. Posibilita la validación de estas representaciones por los propios sujetos de investigación.
6. En relación a esto, los mapas conceptuales son una buena herramienta para acceder y presentar información a los participantes de la investigación, pudiendo utilizarse después otras técnicas de recogida de información o favoreciendo la discusión.
7. Resultan de utilidad para la guía en la técnica de observación.
8. Son una potente herramienta para la captura del conocimiento y su posterior utilización. Los mapas conceptuales pueden resultar un buen instrumento para representar concepciones sobre procedimientos concretos y que estos puedan ser utilizados y consultados por otros profesionales (San Martín et al., 2010). La presentación de la información y sus relaciones facilita el entendimiento y visualización de esta, así, “los mapas conceptuales proporcionan una visión clara del conocimiento del docente con una sola mirada, siendo éstos utilizados tanto para la captura como para la representación del conocimiento obtenido de los docentes.” (de Benito et al., 2012, p.149)
9. Suponen una herramienta eficaz para los estudios longitudinales, ya que permiten la visualización de la evolución de los mapas en base a los datos extraídos en la investigación. Los mapas conceptuales muestran los cambios en el conocimiento y la comprensión individual cuando se trata de estudios longitudinales (Kandiko & Kinchin, 2010).
10. Permite observar las diferencias entre las visiones o concepciones de diferentes participantes en la investigación, como las diferencias en cuanto a si los sujetos son noveles o con experiencia sobre el tema que se estudie o las diferencias en cuanto a un proceso concreto.
11. Los estudios analizados, a excepción de los englobados en el método para la recogida de información, se trata de metodología cualitativa. En este sentido, explorar las potencialidades de los mapas conceptuales en la metodología cuantitativa podría ser una vía para futuras investigaciones.

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ANÁLISIS ESTRUCTURAL DE MAPAS CONCEPTUALES (AEMC): VALORACIÓN CUANTITATIVA DE LA COMPRENSIÓN DEL MODELO DEL OPERÓN EN ESTUDIANTES DE BACHILLERATO

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Abstract El mapa conceptual es una herramienta asociada a la teoría del aprendizaje de Ausubel con muy diferentes usos siendo uno de ellos la evaluación. En este sentido, nosotros aplicamos uno de los procedimientos del Análisis Estructural de Mapas Conceptuales (AEMC) que involucra el uso de pruebas estadísticas. En este trabajo abordamos la técnica del *mapa conceptual cerrado* en conjunción con el tema del *Modelo del Operón*. Este representa un reto de comprensión para alumnos por ser abstracto. Para facilitar el superar este obstáculo, en el ámbito de la enseñanza de la Biología Molecular se sugiere que los estudiantes elaboren modelos; en nuestro caso abordamos dos tipos de modelos: el analógico (MA), que involucra el uso de maquetas y prototipos de material biodegradable, y el digital (MD) que requiere del uso de programas de cómputo. Una duda razonable es si ambos modelos propician al final de su elaboración, el mismo tipo de aprendizaje. En nuestra investigación delimitamos las posibles respuestas a cuáles conceptos del modelo del operón, son recuperados por el estudiante después de haber participado en una actividad que implicó la construcción de un modelo (sea tipo MA ó MD). El AEMC y las pruebas estadísticas aplicadas indican que la mayoría de los estudiantes poseen conocimientos antecedentes del modelo del operón, y que el uso de ambos modelos propicia que los estudiantes identifiquen la estructura y funcionamiento del modelo del operón. Asimismo, la evidencia estadística sugiere que un mayor número de conceptos es asimilado por los estudiantes que emplearon el MD que los que recurrieron al MA.

Keywords: Evaluación, Modelos de aprendizaje, Biología Molecular, AEMC.

1. Introducción

El *Análisis Estructural de Mapas Conceptuales (AEMC)* consiste en un conjunto de técnicas para interpretar y transformar un mapa conceptual en una matriz de asociación o relación. A partir de la sumatoria de matrices individuales se puede obtener una matriz grupal para diferentes tipos de análisis; en este trabajo se utiliza el AEMC como instrumento de evaluación mediante la generación de matrices de conceptos que se capturaron por formularios y/o plantillas en hojas de cálculo. Este tipo de información permitió aplicar la prueba de chi cuadrada (χ^2). Las bases metodológicas del AEMC se encuentran en González *et al.* (2006) y una revisión de sus aplicaciones en Hermosillo *et al.* (2010).

Para los fines de este trabajo se utilizó el *mapa conceptual cerrado*, el cual se elabora mediante la técnica denominada “fill-in-map” (FM). Esta técnica consiste en suministrar al alumno un mapa conceptual experto, al cual se le han eliminado piezas (conceptos, enlaces,...). El mapa conceptual experto es elaborado por un especialista del tema. Para completar el mapa conceptual cerrado, el estudiante tiene que elegir de una lista las piezas que faltan (Ruiz-Primo, 2004). El suministro de la lista de piezas evita problemas de equivalencia semántica entre los elementos propuestos por el estudiante y el mapa experto (Hernández, 2005). De manera consecuente, si se concentra la información de cada mapa conceptual cerrado en un mapa grupal, esto permitirá reconocer repeticiones (por azar o por certidumbre) y contrastar hipótesis de tendencias o patrones (González *et al.*, 2006).

En esta investigación abordamos el tema del *Modelo del Operón* propuesto por Jacob, Monod y Lwoff, el cual es importante desde la perspectiva biológica de cómo se regula a nivel molecular la actividad genética en procariontes. Este contenido se encuentra incluido en el programa de Biología V de la Escuela Nacional Preparatoria (ENP) y constituye un problema de comprensión para alumnos por ser un contenido abstracto al presentar contenidos que hacen referencia a objetos que no son tangibles para el estudiante. Castro (2011) opina que desde una perspectiva didáctica que “si queremos enseñar un tema como la regulación genética, y como ésta no parte de la evidencia observable a simple vista, entonces hemos de basarnos principalmente en la construcción y comprensión de modelos” (p. 106). Asimismo, menciona a la modelización como una estrategia recurrente en la enseñanza de la Biología Molecular, caracterizada en este sentido por utilizar modelos de tipo mecanicistas y moleculares, y añade que éstos permiten acceder a niveles de mayor complejidad, como es el caso del modelo del operón.

Un modelo que pretenda explicar la regulación genética debe tomar en cuenta que los genes no son sólo estructurales, sino también reguladores, lo cual significa una situación dinámica. También nos permite ver las diversas maneras en que se relacionan el medio interno (sistema *Lac* de *E. coli*) con el medio externo (por ejemplo un cultivo rico o pobre en lactosa) y lo más importante, es comprender cómo se autorregula este medio interno (Castro 2011).

Para el presente trabajo se utilizaron dos tipos de modelos para la comprensión del tema regulación genética: El modelo digital (MD) y el modelo analógico (MA). El primero consiste en la construcción de animaciones con el auxilio de programas de cómputo, y el segundo elaborado por medio de maquetas o prototipos tridimensionales con base en materiales de reuso, biodegradables o reciclables. Coincidimos con el punto de vista de Galagovsky y Aduriz-Bravo (2001) quienes consideran a este tipo de modelos (MA o MD), como representaciones concretas las cuales "... involucran una simplificación del concepto científico referente; interpreta sus alcances, aplicaciones y limitaciones, sus escalas de trabajo y el grado de distancia entre el concepto científico propiamente dicho y su representación concreta" (p. 236).

El MD se basa en el uso de las Tecnologías de la Información y Comunicación (TIC), tal es el caso de las animaciones. Dürsteler (2005) las describe como el resultado del proceso de seleccionar una serie de imágenes individuales y concatenarlas en una secuencia temporizada de forma que den la impresión de movimiento continuo. Menciona dos formas de utilizar las animaciones: a) narrativa visual y b) visualización de procesos. Lo que nos interesa en este trabajo es la visualización de procesos, ya que es didácticamente más congruente con el aprendizaje del modelo de operón.

El MA se basa en la construcción de maquetas y prototipos tridimensionales. Conxita-Márquez (2008) considera que desde la perspectiva del estudio de los seres vivos es importante utilizar maquetas, ya que éstas permiten a un estudiante representar aquello que imagina que pasa dentro del cuerpo. Este proceso de construcción de maquetas requiere el uso de un lenguaje representacional con características diferentes del verbal y, por lo tanto, ayuda a concretar ideas, obliga a tomar decisiones sobre los materiales, los colores de las estructuras, las relaciones entre las diferentes partes que constituyen al modelo. La tridimensionalidad favorece el planteamiento de preguntas diferentes y la problematización de aspectos espaciales. Asimismo, la construcción de la maqueta en grupo promueve una comunicación efectiva entre el alumnado, ya que debe tomar decisiones en relación con una problemática común.

De lo anteriormente expuesto, ambos tipos de modelos comparten características pedagógicas de uso. Sin embargo, un planteamiento pertinente es si ambos modelos propician al final de su elaboración el mismo tipo de aprendizaje. En nuestra investigación delimitamos las posibles respuestas a cuáles conceptos del modelo del operón, son recuperados por el estudiante después de haber participado en una actividad que implicó la construcción de un modelo, sea tipo MA ó MD. La herramienta que nos permitió realizar esta comparación fue el mapa conceptual cerrado.

2. Metodología

2.1. Población estudiada

Para el desarrollo de esta investigación se trabajó con una muestra mixta (hombres y mujeres) formada por 89 estudiantes que corresponde a una población que cursan el nivel de bachillerato en el plantel 2 de la Escuela Nacional Preparatoria (ENP), institución educativa que forma parte de la Universidad Nacional Autónoma de México (UNAM). La edad de los estudiantes osciló entre los 17 y 18 años. La muestra se constituyó por cuatro grupos escolares que cursan el 6º ciclo de bachillerato en el área Químico-Biológicas. Se utilizaron dos grupos (en total 47 alumnos) con los cuales se abordó el aprendizaje del modelo del operón con base en la construcción de un modelo tipo MD. Otros dos grupos (en total de 42 alumnos) participaron de forma similar por elaborando un modelo tipo MA. El tema central en la construcción de los MD y MA fue la regulación genética con énfasis en la descripción del modelo del operón (lactosa y triptófano).

2.2 Desarrollo de la estrategia

La actividad de aprendizaje, independiente al tipo de modelo asignado, inició con la lectura extraclase de un fragmento del libro "Genética: la continuidad de la vida" de Barahona y Piñero (1994). La sección que revisaron los alumnos fue *Regulación y control genético: el modelo del operón*, que se encuentra en el capítulo III *Mirando dentro del gene*. La única indicación proporcionada fue que se analizaría esta lectura en clase. En la

primera sesión presencial se le entregó el esqueleto de un mapa conceptual cerrado (Figura 1) con una lista de conceptos del tema de regulación genética basados en la lectura, el cual fue completado en 50 minutos. Los estudiantes no fueron avisados de que tendrían que resolver este mapa, únicamente que se analizaría la lectura ya mencionada. En la sesión de clase posterior, una duración de 50 minutos, se proporcionaron las instrucciones para la elaboración del modelo según fue asignado, y también el espacio de tiempo para que se organizaran los equipos.

Las instrucciones para el MD fueron: a) Colaborar en equipo de 3 o 4 alumnos, b) Elegir algún programa de cómputo que les permitiera hacer animaciones; por la cultura informática de los estudiantes la sugerencia fue utilizar Power Point, c) Representar el modelo de operón de manera dinámica como un proceso utilizando imágenes, figuras o iconos que representaran a cada una de las estructuras moleculares presentes, d) El plazo de tiempo fue una semana para la construcción de la animación.

Las instrucciones en la construcción del MA fueron: a) Trabajar en equipo de 3 o 4 alumnos, b) Elaborar una maqueta o modelo tridimensional con la utilización de material de reuso, biodegradable o reciclable, c) Representar el modelo de operón de manera dinámica como un proceso a partir de los materiales seleccionados y que estos representaran a cada una de las estructuras moleculares presentes, d) El plazo de tiempo fue una semana para la construcción de la maqueta.

En sesiones de clase subsecuentes (100 min), los equipos presentaron en su grupo su modelo elaborado lo cual permitió la discusión grupal y trabajo colaborativo. Como última actividad, en otra sesión de clase (50 min), se les proporcionó el mapa conceptual cerrado sobre el tema de regulación genética para su completado. Al igual que la ocasión anterior no fueron avisados de que tendrían que resolver este mapa.

2.3. *Diseño del mapa conceptual y aplicación del AEMC.*

Se elaboró un mapa conceptual experto a partir del documento de lectura de Barahona y Piñero (1994). El mapa conceptual experto incluyó 21 conceptos, a partir del cual se elaboró una plantilla que conservó tres conceptos como organizadores previos, las frases enlaces y el esqueleto (Figura 1). De manera paralela se elaboró una lista de 24 conceptos en orden alfabético, que incluyó 18 conceptos del mapa experto y 6 conceptos distractores, la cual fue proporcionada junto con la plantilla en el momento de su resolución por cada estudiante.

Las plantillas completadas por los alumnos fueron capturadas en Excel mediante un formulario con una estructura similar a la del mapa experto. Mediante una macro se sistematizó la captura y elaboración de un listado de datos que incluyó los conceptos completados por cada estudiante en su mapa cerrado. Se utilizó la prueba de chi cuadrada χ^2 (Steel y Torrie, 1993) para hacer comparaciones entre las frecuencias obtenidas de los mapas conceptuales cerrados elaborados por los alumnos antes y después de la aplicación de la estrategia de elaboración de MA y MD. Lo anterior permitió detectar aquellos conceptos que fueron significativos estadísticamente por su frecuencia de mención.

3. Resultados

En la tabla 1 se muestran los resultados de la aplicación de la prueba estadística de chi cuadrada (χ^2) a las frecuencias de completado de cada uno de los conceptos de los mapas conceptuales cerrados que resolvieron antes y después de la elaboración de sus modelos. El símbolo MA+MD corresponde al análisis de la población total de alumnos (n=89) sin distinción en la elaboración de los modelos; MA (n=42) corresponde a los grupos de alumnos que elaboraron el modelo analógico y MD (n=47) al grupo de alumnos que elaboraron el modelo digital.

Asimismo, también se observa en la Tabla 1 que para el caso de MA+MD se presentan 11 conceptos que fueron significativos, lo que corresponde al 61% del total de conceptos que incluye el mapa conceptual experto. Para el caso de MA solo 6 conceptos fueron significativos con un porcentaje del 33% del total de conceptos del mapa experto. Con relación a MD, presentó 10 conceptos significativos, lo cual se traduce en un porcentaje del 55% del total de conceptos del mapa experto. Al aplicar la prueba de estadística chi cuadrada (χ^2) comparando los conceptos significativos entre MA (6) y MD (10), se obtiene un valor calculado de 14.8 ($\chi^2=3.84$; gl=1; $p>0.05$), lo cual se interpreta en el sentido de que existe una diferencia significativa entre el uso de ambos modelos, al menos en la cantidad de conceptos que recuperan los estudiantes, una vez que terminan la actividad.

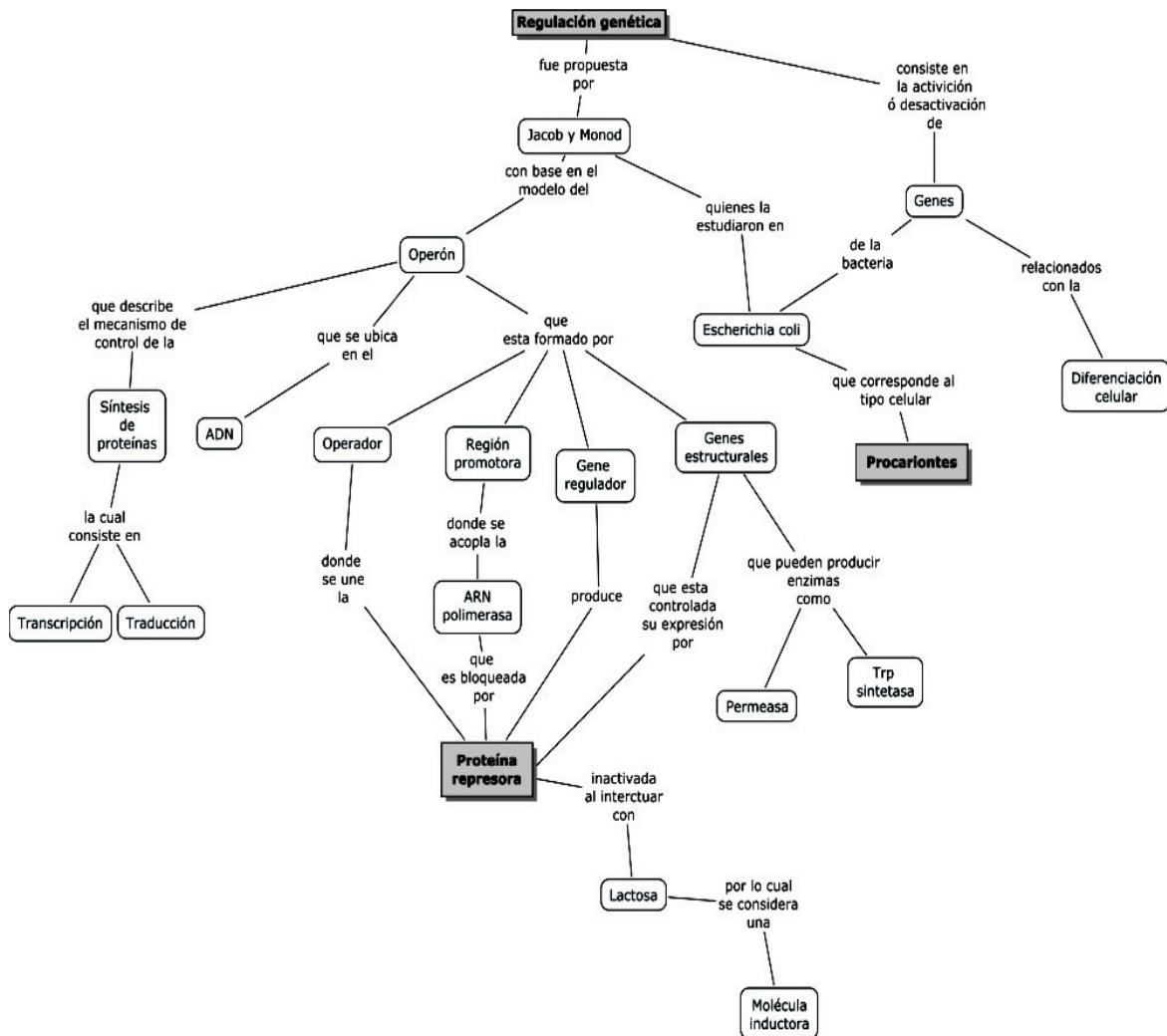


Figura. 1: Mapa conceptual cerrado experto (Las casillas sombreadas corresponden a los conceptos que permanecieron en la plantilla de captura)

Tabla. 1: Valores de chi cuadrada - χ^2 - obtenidos de la comparación de los resultados de las aplicaciones de mapas conceptuales cerrados elaborados por los alumnos, antes y después de la construcción de los modelos (MA+MD=total de alumnos sin distinción en la elaboración de los modelos; MA=grupo de alumnos que elaboraron el modelo analógico; MD=grupo de alumnos que elaboraron el modelo digital; $\chi^2=3.84$; gl=1; p>0.05)

Conceptos	MA+MD	MA	MD
JACOB Y MONOD	2.2	2.313	1.044
OPERÓN	0.8	2.097	0.123
GENES	0.3	1.199	0.000
ESCHERICHIA COLI	9.2	6.818	2.712
SÍNTESIS DE PROTEÍNAS	2.2	0.002	3.519
ADN	13.0	10.499	4.304
OPERADOR	20.0	4.420	19.077
REGIÓN PROMOTORA	23.0	2.677	26.644
GENE REGULADOR	8.0	4.261	4.608
GENES ESTRUCTURALES	25.0	12.470	13.022
DIFERENCIACIÓN CELULAR	0.7	0.007	1.081
TRANSCRIPCIÓN	3.9	0.006	6.425
TRADUCCIÓN	9.7	1.423	6.425
ARN POLIMERASA	35.0	14.888	20.680
PERMEASA	13.0	1.427	15.017
TRP SINTETASA	2.1	0.335	0.758
LACTOSA	10.0	2.700	8.134
MOLÉCULA INDUCTORA	0.6	0.032	0.949

La figura 2 permite detectar en el mapa conceptual experto la ubicación de los conceptos que fueron significativos para MA+MD (a), MA (b) y MD (c). Para un mejor interpretación de la ubicación de los porcentajes de conceptos que completaron los estudiantes, el mapa conceptual experto se dividió en dos regiones con base en la información que presenta el mapa. Estas regiones corresponden a: 1) *los antecedentes del tema regulación genética* y 2) *a la descripción de la estructura del modelo del operón*.

Se detectó que en la primera región cinco conceptos no fueron significativos, los cuales son: síntesis de proteínas, operón, Jacob y Monod, genes y diferenciación celular. Cabe destacar que los primeros cuatro conceptos presentaron porcentajes de mención de conceptos superiores al 70%, tanto *antes* como *después* de la elaboración de los modelos. Para el caso del concepto de diferenciación celular, sus porcentajes de mención fueron desde 51% para *antes* hasta 64% para *después*. Asimismo, cuatro conceptos presentaron diferencias significativas que son: transcripción, traducción, ADN y *Escherichia coli*. Se destaca ADN por haber sido significativo en a, b, y c, con valores de porcentaje que oscilan entre 51% y 90%.

En la segunda región es en donde se presentó el mayor número de conceptos con diferencias significativas en alguna de las modalidades M+A, MA o MD. Fueron siete los conceptos con esta característica: *operador*, *región promotora*, *gene regulador*, *genes estructurales*, *ARN polimerasa*, *permeasa* y *lactosa*. La frecuencias de mención para estos conceptos van desde 19% en “antes” (lactosa) hasta 93% para “después” (genes estructurales). Solo dos conceptos no presentaron diferencias significativas en sus frecuencias de mención de conceptos, éstos son: *TRP sintetasa* y *molécula inductora*, siendo ésta última la que presentó los valores de porcentaje más bajos que van desde 19% al 29%.

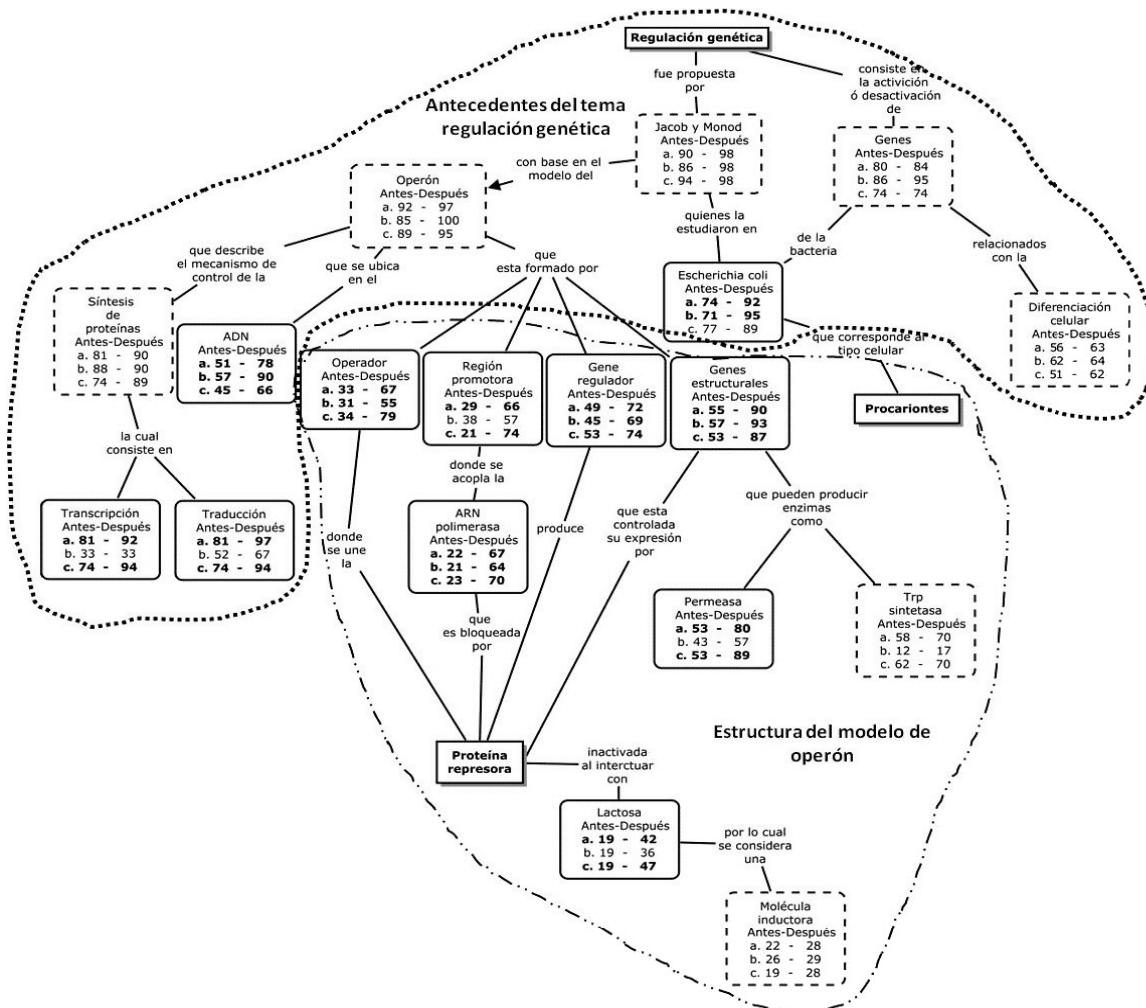


Figura. 2: Mapa conceptual cerrado experto que representa las frecuencias porcentuales (%) de los conceptos seleccionados por los alumnos antes y después de la elaboración de los modelos; a= MA+MD, b=MA, c=MD. Los valores en negritas corresponden a datos que fueron significativos de acuerdo a la prueba de chi cuadrada (MA+MD=total de alumnos sin distinción en la elaboración de los modelos; MA=grupo de alumnos que elaboraron el modelo analógico; MD=grupo de alumnos que elaboraron el modelo digital; $\chi^2=3.84$; gl=1; $p>0.05$)

4 Discusión

La tabla 1 aporta información estadística comparativa acerca de los grupos que elaboraron el modelo digital y el modelo analógico. Al final de la actividad, los grupos que elaboraron el modelo digital presentaron un mayor número de estudiantes, que fueron capaces de identificar y colocar un mayor número de conceptos en las

casillas correspondientes del mapa conceptual experto. Una posible explicación a esta diferencia puede estar relacionada con el hecho de que las animaciones permiten la visualización de procesos dinámicos, lo cual es importante el caso de la Biología. Dürsteler (2000) destaca las ventajas de representar acontecimientos y/o procesos utilizando el movimiento y la animación: a) La animación permite representar efectivamente la causalidad, b) Los actos que expresan comunicación o flujo se explican mejor mediante animaciones, c) Una estructura se puede transformar gradualmente utilizando la animación haciendo explícitas las etapas de la reorganización, y d) Secuencias de acciones espaciales complejas se pueden representar de forma muy clara mediante la animación.

Para el caso de la figura 2, la mayor parte de los conceptos se ubican en la región de *antecedentes del tema regulación genética*. Con base en los resultados estadísticos, estos se pueden considerar como conocimientos previos que el alumno tenía antes de llenar la plantilla del mapa conceptual cerrado, ya sea porque los adquirió de la lectura de Barahona y Piñero o porque los había visto en otro momento. Resalta como resultado, el que posterior a la construcción de los modelos, el alumno asoció el concepto operón con la molécula de ADN, lo cual es fundamental para entender la regulación genética y el modelo del operón.

La región que corresponde a la *descripción de la estructura del modelo del operón* (figura 2) presentó más conceptos que fueron significativos. La interpretación a lo anterior es que la elaboración de los modelos digitales y analógicos les permitió a los alumnos comprender de una manera adecuada los elementos que constituyen al modelo del operón, tal es el caso de los conceptos *operador*, *gene regulador*, *genes estructurales* y *ARN polimerasa*. Sin embargo algunos de estos conceptos presentan una frecuencia de mención de 55% al 70% en la segunda aplicación de la plantilla del mapa conceptual cerrado, por lo que se requiere un ajuste y asesoramiento durante la estrategia de elaboración de modelos para lograr incrementar dichos porcentajes. Aparentemente la participación de los alumnos en la elaboración del modelo digital promovió la asimilación de un mayor número de conceptos con respecto al modelo analógico; de forma estadística, los alumnos que elaboraron el modelo digital recuperaron al menos siete conceptos en la región *descripción de la estructura del modelo del operón*, mientras que los alumnos que elaboraron modelo analógico solo recuperaron cuatro conceptos.

Los resultados obtenidos a partir de la utilización de los modelos analógico y digital apoyan lo mencionado por Castro (2011) en el sentido de que “...los modelos son construcciones que no nos dicen exactamente cómo es y cómo se comporta el sistema que estamos estudiando, pero sí nos dan indicios de que, dados los conocimientos teórico-prácticos de la ciencia en un determinado momento, esas son las mejores representaciones de las que disponemos. Y una vez que éstas demuestran su pertinencia, entonces no es extraño que devengan en objetos de enseñanza, en diferentes niveles de la educación formal.” (p. 107)

Se debe prestar atención a los conceptos de *diferenciación celular*, *TRP sintetasa* y *molécula inductora* debido que la utilización de la estrategia de elaboración de modelos, permitió de forma parcial que los alumnos hicieran uso de los mismos al momento de llenar sus mapas conceptuales cerrados.

5 Conclusiones

La utilización de la técnica de AEMC permitió evaluar la utilización de modelos del tipo MA y MD relacionados con el tema de regulación genética en una población estudiantil de bachillerato. Las estrategias de elaboración de MA y MD proporcionan los elementos necesarios al alumno, para que comprenda de una manera adecuada la estructura del modelo del operón. Sin embargo, es necesario diseñar estrategias de complemento que permita que un mayor número de alumnos entiendan las características de este modelo. Aparentemente la estrategia de elaboración de modelos MD propicia que un mayor número de estudiantes identifique y asocie, un mayor número de conceptos involucrados en el proceso de regulación génica.

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APLICACIÓN DEL AEMC EN MAPAS CONCEPTUALES ELABORADOS AL FINAL DE UN CURSO DE BIOLOGÍA PARA ESTUDIANTES DE BACHILLERATO

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Resumen: En esta ponencia utilizamos los mapas conceptuales como un procedimiento para explorar la forma en que estudiantes de bachillerato asociaban conceptos mínimos de un curso anual de Biología. La elaboración de los mapas ocurrió al final del curso con base en un listado de palabras y metodología que fue obtenida de una investigación publicada en 2004. Para el análisis de resultados se utilizó el Análisis Estructural de Mapas Conceptuales (AEMC) y también se realizó la comparación con los datos de la publicación ya mencionada. Se ubicaron ocho conceptos dominantes para los mapas conceptuales analizados y que comparados con la publicación ya citada, mostró tres conceptos comunes: Célula, Ecosistema y Reproducción. Aunque el concepto de Ciencia es importante para articular el resto de los conceptos, este fue clasificado como ocasional en esta investigación y la del 2004. Se propone un análisis de las frases que conectan a los conceptos más frecuentemente asociados, el cual corroboró parte de los resultados obtenidos con el AEMC.

Palabras Claves: Evaluación, Programas de estudios, AEMC.

1 Introducción

Moreira (2010) menciona que usar mapas conceptuales constituye “una estrategia facilitadora del aprendizaje significativo y de la conceptualización” (p. 17), por otra parte los mapas conceptuales han sido empleados como un instrumento exploratorio de la forma en la cual los estudiantes estructuran sus ideas (Ladislada del Puy, 2012). Cuando un grupo está constituido por muchos alumnos un problema práctico es cómo procesar la información generada por tantos mapas conceptuales.

Una herramienta útil en este sentido es el Análisis Estructural de Mapas Conceptuales (AEMC). Este instrumento permite, entre otros aspectos, integrar los mapas conceptuales que producen cada uno de los estudiantes en un mapa conceptual colectivo o grupal. Lo anterior se logra mediante la transformación de las proposiciones de cada mapa conceptual individual en un arreglo de renglones y columnas (matriz de asociación o matriz de datos). De esta forma, al sumar las matrices individuales se obtiene una matriz colectiva. A partir de la matriz grupal se puede optar por realizar diferentes análisis (gráficos Olmstead-Tukey, pruebas estadísticas, mapa conceptual colectivo), en los cuales se puede sustentar la toma de decisiones con respecto a un proceso de aprendizaje. El AEMC ha sido empleado como mecanismo de diagnóstico y evaluación de métodos o estrategias de aprendizaje, y en general es un mecanismo auxiliar para interpretar el significado colectivo del mapa conceptual que elaboran o completan estudiantes. El AEMC fue presentado en la publicación de González *et al.* (2006) y una revisión de sus aplicaciones se encuentra en Hermosillo *et al.* (2010). Sin embargo, el primer esbozo de esta herramienta fue presentado en González *et al.* (2004).

En esta ponencia retomamos esta primera publicación para realizar un análisis similar y profundizar en aspectos que no fueron abordados en ese momento, como el análisis de las frases enlace. Otra precisión es que los datos a comparar son de generaciones con una diferencia en dos décadas, ya que los datos empleados en González *et al.* (2004) fueron recolectados en 1994. En el trabajo de González *et al.* (2004) se utilizaron los mapas conceptuales para explorar la forma en que los alumnos de la muestra seleccionada asociaban palabras o conceptos esenciales en el contexto del programa de Biología IV de la Escuela Nacional Preparatoria (ENP) de la Universidad Nacional Autónoma de México (UNAM). Este programa se sustituyó en 1996 por otro programa de estudios que conservó, para la asignatura de Biología IV, casi la totalidad de los contenidos. La diferencia se encuentra en un replanteamiento de abordaje de los contenidos con un enfoque de aprendizaje constructivista así como una reestructuración en el orden de los contenidos.

Por lo anterior, fue de nuestro interés aplicar la metodología del trabajo de González *et al.* (2004) a una muestra de la generación del 2014 y valorar si existían diferencias perceptibles entre ambas generaciones mediante el AEMC. Un punto clave fue la lista de palabras que se utilizó en el trabajo de González *et al.* (2004) para que los estudiantes elaboraran su mapa conceptual. Al analizarla, consideramos que era equivalente y válida, en el sentido de constituir un conjunto de conceptos mínimos que debe aprender un estudiante para el actual programa de estudios. Por otra parte también analizamos el tipo de asociaciones que se establecieron

entre los conceptos con un porcentaje de frecuencia de asociación mayor al 60% para tener otra perspectiva de interpretación, y enriquecer el AEMC.

2 Metodología

Este trabajo se realizó durante el ciclo escolar 2013-2014 con una población 31 estudiantes que cursaron la asignatura de Biología IV de 5º año de bachillerato. Para este trabajo no se consideró el tipo de escuela de la cual egresaron los estudiantes que participaron en la muestra, por ser muy pequeña, aunque se tomó nota de lo anterior para elaborar las tablas comparativas.

Durante el curso los estudiantes aprendieron a elaborar mapas conceptuales y el dato importante al respecto es que la construcción de los mapas conceptuales que analizamos en esta ponencia se elaboró al final del curso, para proporcionar un panorama de cómo estructuraron los estudiantes los conceptos proporcionados después de haber cursado la signatura de Biología IV.

La elaboración de los mapas conceptuales consistió en:

- Proporcionar la lista de 20 palabras ordenadas alfabéticamente y que corresponde al trabajo de González *et al.* (2004)
- Solicitarles que elaboraran un mapa conceptual en 50 minutos de clase con papel y lápiz. Esta lista se puede observar en la matriz de datos de la tabla 1. Una vez terminado ese lapso de tiempo entregaron su mapa conceptual elaborado.
- Los mapas conceptuales fueron revisados para detectar ambigüedades como el tipo de frases que empleaban o dificultades para interpretar el significado de las proposiciones en el mapa conceptual.
- En una sesión posterior se devolvió a cada estudiante el mapa conceptual que había elaborado. A continuación se le brindó asesoría sobre aspectos detectados en la construcción de su mapa conceptual
- Estas asesorías fueron grabadas en audio para complementar el análisis, aunque no forman parte de los resultados presentados en esta ponencia.
- Por último, se le solicitó al estudiante que con base en la asesoría brindada, reconstruyese su mapa conceptual y que lo trasladase a un formato digital para su entrega facilitando así su interpretación,

Un análisis preliminar de los mapas fue clasificar a los mapas elaborados mediante los criterios de la Taxonomía tipológica propuesta por Cañas y Novak (2006). Esto nos permitió garantizar que los mapas tenían un nivel aceptable en su estructura de construcción para ser incluidos en la investigación. Posteriormente los mapas conceptuales fueron procesados mediante el AEMC, transformando cada mapa en una matriz individual y obteniendo la matriz grupal y la gráfica de Olmstead-Tukey respectiva.

3 Resultados y discusión.

En la tabla 1 se muestran las frecuencias y porcentajes de los mapas conceptuales clasificados de acuerdo a los niveles propuestos por la taxonomía topológica de Cañas y Novak (2006). De acuerdo a la tabla 87% de los mapas conceptuales presentaron un nivel de 3 o 4, lo cual es un indicador de que los mapas analizados presenten una calidad aceptable para el análisis que efectuamos.

Tabla 1: Resultado de la clasificación de los mapas conceptuales elaborados por los estudiantes utilizando los criterios de la Taxonomía Topológica propuesta por Cañas y Novak, (2006)

Nivel Taxonómico	Frecuencia	Porcentaje
3	11	35
4	16	52
5	4	13
Total	31	100

En la Figura 1a, 1b y 1c se presentan ejemplos de los mapas conceptuales elaborados. La mayoría de los estudiantes eligió empezar la construcción del mapa a partir del concepto de ciencia o relacionado directamente con la misma. En la mayoría de los mapas conceptuales, los primeros conceptos que asocia tienen un vínculo directo con la primera unidad vista en el curso de Biología IV, la cual se titula *La Biología como ciencia*. El resto de los conceptos no reflejan de forma evidente el bloque de conceptos asociados a una unidad determinada.

En la tabla 2 se presenta la matriz de asociación resultante de los 31 mapas analizados. A partir de esta matriz se construyó la gráfica de Olmstead-Tukey que se muestra en la figura 2. La matriz de asociación

también fue útil para determinar cuáles de las asociaciones fueron las más empleadas por los estudiantes y que son analizadas y representadas en otra tabla posterior. La gráfica de Olmstead-Tukey muestra los conceptos clasificados en las cuatro categorías (Dominantes, Ocasionales, Constantes y Raros). Con base en esta información se procedió a realizar la comparación con los datos del trabajo de González *et al.* (2004) y que se muestran en la tabla 3.

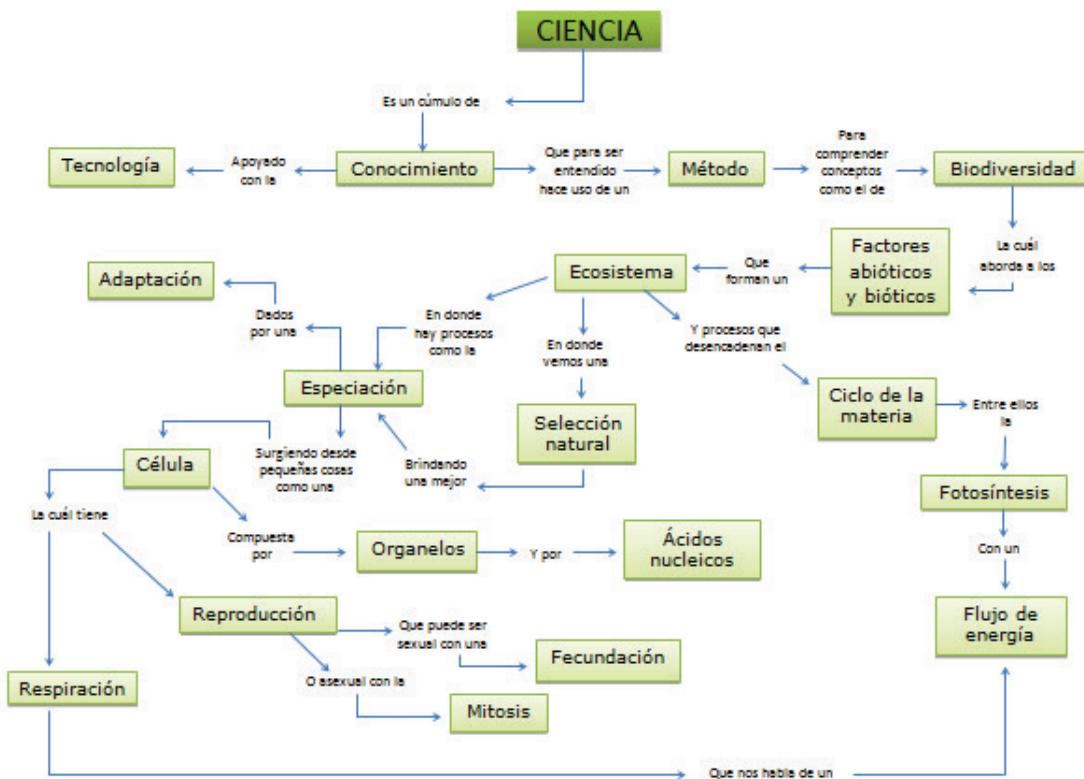


Figura 1a: Ejemplo de mapa conceptual elaborado por los estudiantes con el concepto de ciencia jerarquizado como el más importante.

De la revisión y análisis de esta tabla 3 fue que se decidió enfocarse a los conceptos dominantes y realizar la comparación de las tres poblaciones mencionadas en el trabajo de González *et al.* (2004), las cuales se muestran en la tabla 4. Tres conceptos resultaron comunes para estas poblaciones: *Célula*, *Ecosistema* y *Reproducción*.

Los dos programas de estudios coincidieron en incluir los aspectos relacionados con el concepto de ciencia en la primera unidad. En el caso del concepto de *Ecosistema* es abordado de forma secuencial distinta en los dos programas; en el programa anterior se ubicó al tema de ecosistema en la segunda unidad, en tanto que en el programa actual corresponde a la última unidad. El concepto de *Reproducción* coincide en ambos programas en ser abordado en la tercera unidad. El concepto de *Ciencia*, a pesar de no ser dominante en las diferentes poblaciones también coincidió en ser ubicado como ocasional.

En el trabajo de González *et al.* (2004) se sugería que el esfuerzo del docente se debería encaminar a establecer mayor número de relaciones que permitieran que el concepto de ciencia se ubicaría de ser un concepto ocasional a uno dominante. Sin embargo, con base en la evidencia de esta investigación, consideramos que el que sea ocasional se debe a que el concepto es ubicado en la mayor jerarquía posible, por lo cual difícilmente en esa posición establecería un mayor número de relaciones que lo trasladarían a la categoría de *Dominio*.

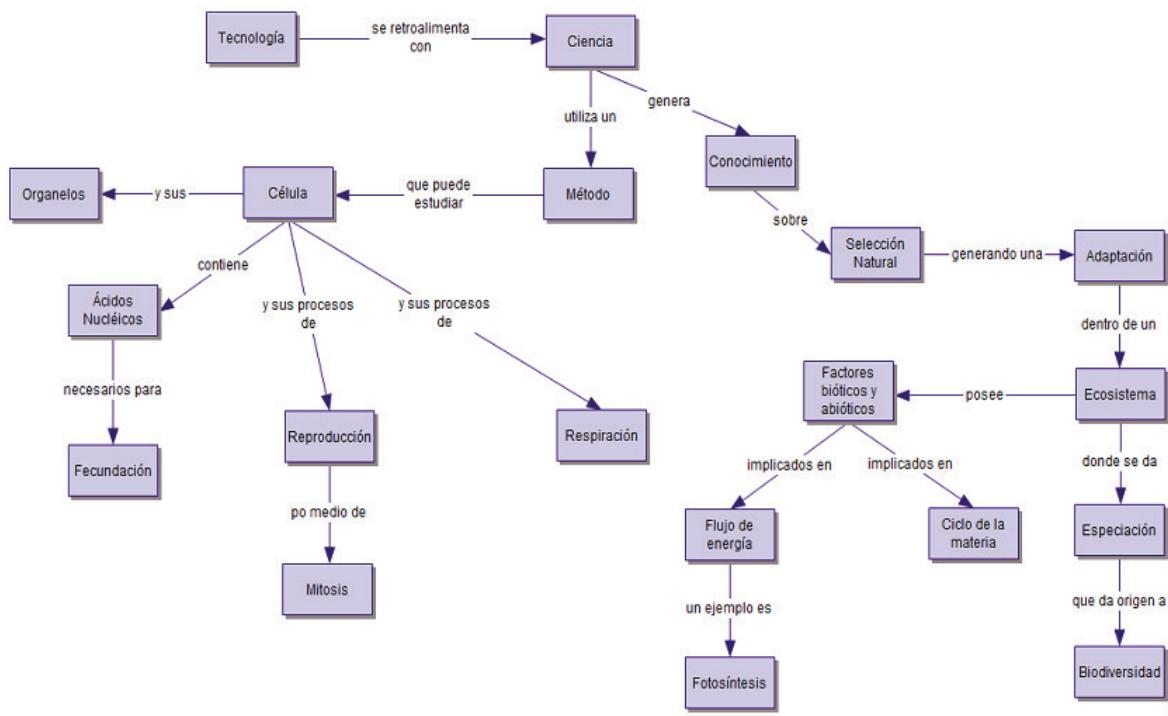


Figura 1b: Ejemplo de mapa conceptual elaborado por los estudiantes con el concepto de tecnología jerarquizado como el más importante.

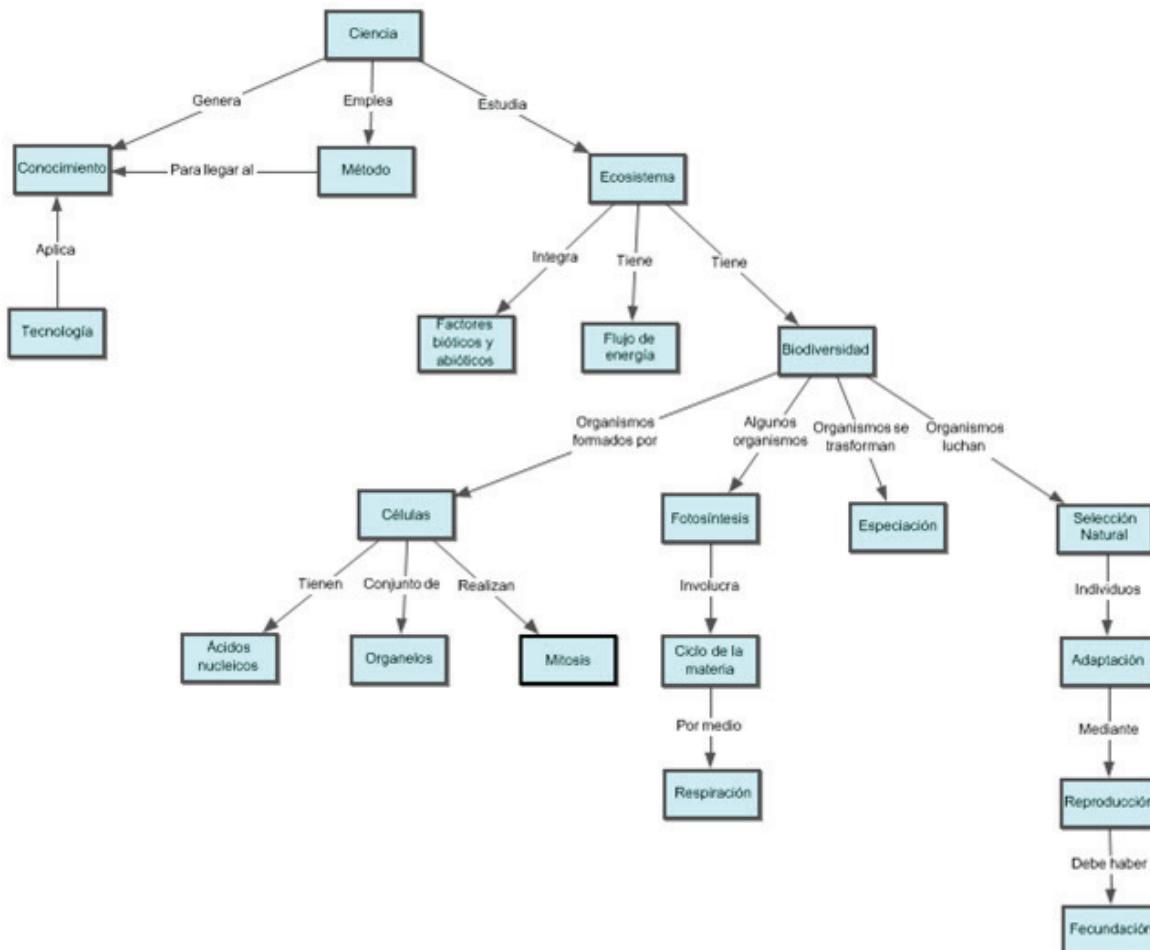


Figura 1c: Ejemplo de mapa conceptual elaborado por los estudiantes con el concepto de ciencia jerarquizado como el más importante.

En la tabla 5 se muestran un conjunto de caracterizaciones teóricas de los conceptos obtenidas en libros de bachillerato que consultaron los estudiantes en el curso. Estas argumentaciones nos sirvieron como parámetro para analizar las frecuencias de asociación más *populares* (mayor a 60%) entre los mapas conceptuales analizados.

En la tabla 6 se presenta el análisis de estas asociaciones clasificadas en dos categorías de acuerdo al conector o frase utilizada: *Incompleto* y *Adecuado*. Se consideró incompleto cuando el conector empleado en la proposición no era equivalente a los argumentos específicos mostrados en la tabla 5, ya fuese porque estuviese ausente alguna característica relevante o en estuviese en contradicción. Se consideró adecuada la asociación si era equivalente con los argumentos específicos de la tabla 5.

Tabla 2: Matriz de asociación grupal entre los 20 conceptos del programa de Biología IV. Las casillas sombreadas corresponden a las relaciones más altas entre los conceptos.

Destaca nuevamente el concepto de *ciencia* a pesar de no ser dominante, sino ocasional de acuerdo a la prueba de Olmstead-Tukey, y que corrobora lo mencionado anteriormente para el bloque de conceptos asociados con *ciencia*. De acuerdo a este análisis el concepto de *ecosistema* es clave para los estudiantes del curso de Biología IV por ser frecuentemente asociado y su adecuada forma de ser incorporado.

Consideramos que este sería un concepto previo que se debe abordar en conjunción con *ciencia*, quizá como ejemplo de aplicación de los conceptos de *Ciencia, Tecnología, Método Científico y Conocimiento*. El concepto de *Reproducción* presenta mayor número de asociaciones inadecuadas, en particular con el concepto de *Fecundación*. Quizá esto se debe a que otros estudios han señalado que constituye una concepción alternativa (Banet, 2000; Jiménez, 2007), y que es difícil de abordar.

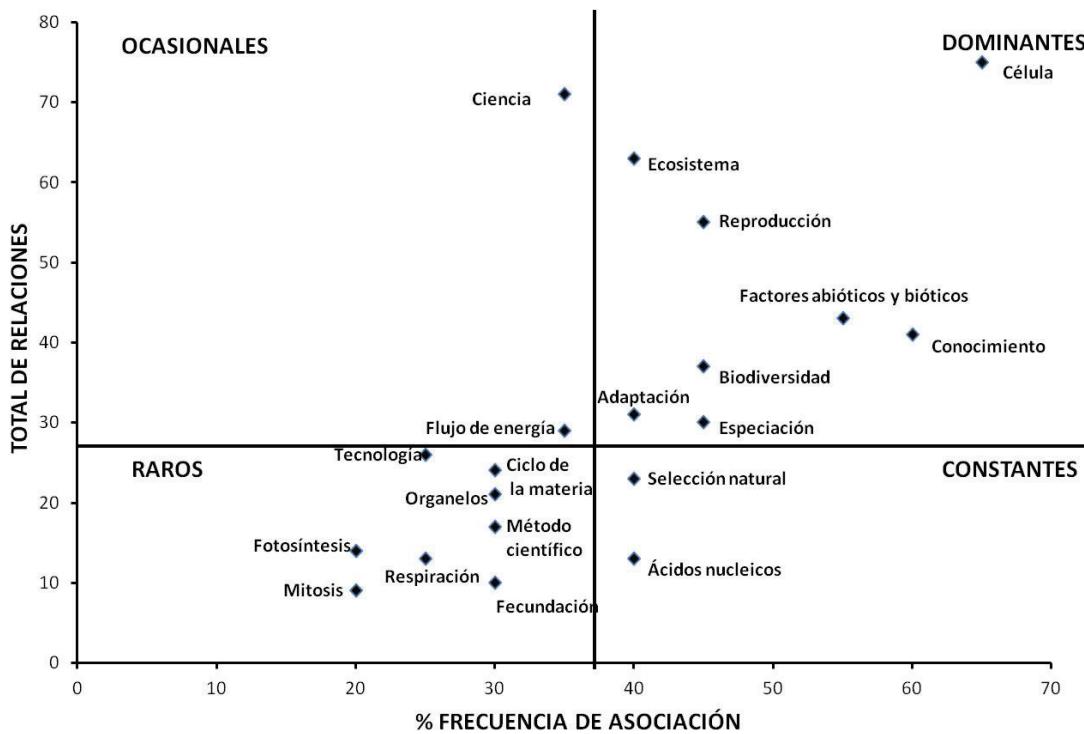


Figura 2: Clasificación de los conceptos mediante la prueba de asociación Olmstead-Tukey, aplicación 2014.

Tabla 3: Comparación de la clasificación de los conceptos de Biología obtenidos por medio de la prueba de asociación Olmstead-Tukey. Los datos corresponden a la aplicación en 2014 y de la referencia de González et al. (2004); estos últimos están ubicados por sector educativo de acuerdo a esta fuente.

Datos de la presente publicación			
Conceptos Dominantes	Conceptos Ocasionales	Conceptos Constantes	Conceptos Raros
biodiversidad	ciencia	ácidos nucleicos	método científico
célula	flujo de energía	selección natural	ciclo de la materia
conocimiento			fecundación
ecosistema			fotosíntesis
factores abióticos y bióticos			mitosis
reproducción			organelos
adaptación			respiración
especiación			tecnología
Datos de González et.al. 2004			
SEP			
célula	ciencia	adaptación	tecnología
ecosistema	conocimiento	fotosíntesis	especiación
reproducción	biodiversidad	factores abióticos y abióticos	ciclo de la materia
fecundación	método científico	respiración	organelos
selección Natural		mitosis	ácidos nucléicos
		flujo de energía	
Iniciación			
célula	ciencia	fotosíntesis	fecundación
ecosistema	conocimiento	adaptación	organelos
tecnología	reproducción	ciclo de la materia	flujo de energía
biodiversidad	método científico		mitosis
selección natural			especiación
			respiración
			factores abióticos y abióticos
			ácidos nucléicos
Particular			
célula	ciencia	ciclo de la materia	selección natural
ecosistema	conocimiento	fotosíntesis	fecundación
reproducción			método científico
biodiversidad			especiación
factores abióticos y abióticos			tecnología
adaptación			ácidos nucléicos
			mitosis
			organelos
			flujo de energía
			respiración

Tabla 4: Comparación de la clasificación de los conceptos *dominantes* de Biología, obtenidos por medio de la prueba de asociación Olmstead-Tukey. Los datos corresponden a la aplicación en 2014 y de la referencia de González et al. (2004); estos últimos están ubicados por sector educativo de acuerdo a esta fuente.

CONCEPTOS DOMINANTES	2014			Fuente González et al. 2004		
		SEP	INICIACIÓN	PARTICULAR		
Biodiversidad	●		●	●		
Célula	●	●	●	●		
Conocimiento	●					
Ecosistema	●	●	●	●		
Factores bióticos y abióticos	●			●		
Reproducción	●	●		●		
Adaptación	●			●		
Especiación	●					

Tabla 5: Definiciones basadas en textos del bachillerato de conceptos con un porcentaje de frecuencia de asociación mayor al 60%.

Asociación de Conceptos	
Ecosistema Los organismos de una comunidad y los factores abióticos asociados con los que están en interacción.	Factores bióticos Un componente vivo de una comunidad biológica, un organismo o un factor que están relacionados con un organismo u organismos. Factores abióticos Un componente no vivo de un ecosistema, tal como el aire, el agua o la temperatura.
Ciencia Campo del conocimiento, cuerpo de conocimientos, conjunto de teorías o explicaciones o como una actividad de investigación. Conjunto de conocimientos objetivos y verificables.	Tecnología Conjunto de conocimientos de orden práctico y científico que son utilizados para la obtención de bienes de utilidad práctica que pueden satisfacer las necesidades.
Reproducción Cualquier proceso reproductor, como la gemación o la división de una célula o de un organismo en dos o más partes aproximadamente iguales, en la que no intervienen la unión de gametos (Reproducción asexual)	Mitosis División nuclear caracterizada por la replicación de los cromosomas y la formación de dos núcleos hijos idénticos.
Célula Unidad estructural de los organismos, rodeada por una membrana y compuesta por citoplasma y en los eucariontes uno o más núcleos.	Organelos Cuerpo rodeado por membrana que se encuentra en el citoplasma de una célula.
Reproducción Reproducción en la que intervienen la meiosis y la fecundación (Reproducción sexual)	Fecundación Fusión de dos núcleos gaméticos haploides, forman el núcleo de un cigoto diploide.
Ciencia Es un campo del conocimiento, cuerpo de conocimientos, conjunto de teorías o explicaciones o como una actividad de investigación. Conjunto de conocimientos objetivos y verificables.	Método científico Conjunto de procedimientos y técnicas para alcanzar el conocimiento de un objeto.
Ciencia Campo del conocimiento, cuerpo de conocimientos, conjunto de teorías o explicaciones o como una actividad de investigación. Conjunto de conocimientos objetivos y verificables.	Conocimiento Proceso social mediante el cual el hombre elabora explicaciones acerca del mundo en que vive.

Tabla 6: Análisis de la proposición de aquellos conceptos asociados que presentaron al menos 60% de porcentaje de frecuencia de asociación.

Asociación de Conceptos		Frecuencia	% de frecuencia	% Incompleto (a)	% Adecuado (b)
Ecosistema	Factores bióticos y abióticos	25	81	0	100
Ciencia	Tecnología	24	77	0	100
Reproducción	Mitosis	22	71	23	77
Célula	Organelos	22	71	14	86
Reproducción	Fecundación	21	68	57	43
Ciencia	Método científico	21	68	14	86
Ciencia	Conocimiento	19	61	11	89

Nota:

(a) Se consideró que un conector estaba incompleto si, la proposición que formaba carecía de al menos un elemento que permitiera inferir una argumentación científica válida.

(b) Se consideró que un conector era adecuado si, la proposición que formaba no contradecía o se oponía, al significado científico de la asociación de conceptos analizados.

4 Conclusiones

De acuerdo a los análisis realizados con el AEMC, el concepto de *Ciencia* es fundamental para la comprensión de un curso general de Biología para el bachillerato, ya que permite articular conceptos específicos de la Biología. Otros dos conceptos claves son los asociados con *Célula* y *Ecosistema*. El análisis de las frases que conectan a los conceptos nos permitió corroborar las anteriores afirmaciones derivadas del AEMC. Consideramos que esta puede ser una nueva herramienta que permite el análisis semántico en el contexto del AEMC.

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APORTES DE LA TEORÍA DE LA CARGA COGNITIVA EN EL DISEÑO DE MATERIALES DE INSTRUCCIÓN

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Resumen. La presente investigación muestra el efecto de diversos formatos instruccionales tales como el texto, los mapas conceptuales o la combinación de ambos en la transferencia de aprendizajes a situaciones nuevas. En este estudio experimental participaron 144 estudiantes estadounidenses de psicología los cuales fueron seleccionados aleatoriamente. Se consideraron como variables los conocimientos previos, estilos de aprendizaje y los materiales instructoriales, para tratar de determinar en qué medida sujetos con bajos conocimientos previos, o con estilo de aprendizaje visual aprendían cuando se utilizaba un formato instructional en texto o en mapa conceptual. La teoría de la carga cognitiva de Sweller (1994, & 2004), apoyó este estudio, la cual sostiene que la enseñanza de estructuras y esquemas complejos requiere que se analicen las limitaciones del sistema de procesamiento de información humana, lo que tiene consecuencias para el diseño de material instruccional. En complemento con esta teoría se consideraron los supuestos de Ausubel (1960), quien sugirió que las estructuras de conocimientos preexistentes en el aprendiz eran cruciales para la retención de información dentro de un contexto de aprendizaje. Los resultados obtenidos sustentan la tesis de que el diseño de materiales de instrucción debe ser planeado atendiendo a los conocimientos previos, los estilos cognitivos del sujeto y a su estructura cognitiva; atendiéndose de esta manera las limitaciones del sistema de memoria.

Palabras Claves: Formatos de instrucción, Estilos de aprendizaje, Transferencia de aprendizaje, Conocimientos previos, Estructura cognitiva humana.

1. Introducción

Por años, investigaciones en el área educativa, psicología, neurolingüística, tecnológica, entre otras, se han enfocado en conocer como aprende y procesa información el ser humano, sin embargo, es la contribución de cada una de estas disciplinas las que han permitido conocer más sobre este fenómeno tan complejo. En los últimos años se ha observado una extensa línea de investigación que ha girado en torno al conocimiento de estructuras y procesos cognitivos, proporcionado una nueva fuente para el sustento de hipótesis asociadas con principios del diseño de instrucción (Sweller, 1994; Sweller & Chandler, 1994; van Merriënboer & Sweller, 2010). Esto ha facilitado probar hipótesis sobre cómo organizar la información a ser aprendida en función de la estructura cognitiva del que aprende a fin de potenciar el logro del aprendizaje efectivo.

Uno de los propósitos de este trabajo de investigación está relacionado con la búsqueda de una explicación teórica-metodológica que sustente la tesis de cómo aprende el ser humano y cómo transfiere lo aprendido a una nueva situación. Especialmente, sobre cómo influyen los formatos de instrucción en la adquisición de nuevos esquemas. La teoría de la carga cognitiva (TCC), enfatiza sobre las limitaciones de la memoria de trabajo (MT) como determinantes en la eficacia del diseño instruccional (Sweller, 1994; van Merriënboer & Sweller, 2010; Paas & Ayres, 2014). Como principio, esta teoría parte del análisis de la arquitectura cognitiva humana, y la interacción entre MT y memoria a largo plazo (MLP) en la formación y automatización de nuevos esquemas, lo que luego, con la práctica deliberada va a contribuir a la generalización y transferencia del conocimiento. Uno de los pilares principales de esta teoría es la concepción de que la memoria de trabajo es limitada en capacidad de 4 ± 1 elementos de información (Baddeley, 1986; Miller, 1956). Esta teoría apoya la idea de que un material de instrucción diseñado eficaz y eficientemente, evita la sobrecarga de la memoria de trabajo, contribuye a la formación de esquemas en la memoria a largo plazo, orientando la atención del estudiante en procesos de aprendizaje relevantes.

En esta búsqueda de respuestas de cómo el humano organiza información y aprende, han surgido muchas propuestas teóricas; por ejemplo, las propuestas de Ausubel sobre el aprendizaje significativo, y la propuesta del uso de los organizadores avanzados como estrategias para fomentar este tipo de aprendizaje (Novak & Gowin, 1984), de allí han surgido muchas investigaciones sobre el uso y aplicación de estrategias tales como los esquemas, los gráficos, los mapas de conceptos, entre otros.

Una de las estrategias a las que se le ha dado mayor atención para el aprendizaje de las ciencias es el mapa de conceptos (Novak, 1998). La estrategia consiste en presentar conceptos en formas de nodos y establecer relaciones en forma de redes lógicas y secuenciales que explican un área o dominio determinado. Recientemente hay un creciente interés por indagar la efectividad del uso de los mapas de conceptos en ambientes

computarizados, encontrándose que hay diferencias significativas entre estudiantes que usan un software y aquellos que usan papel y lápiz para generar un mapa. Se observa mayor complejidad en la estructura de los mapas cuando los estudiantes usan el computador que cuando los generan a través del uso del papel y lápiz (Royer & Royer, 2004).

2. Planteamiento del Problema

El problema radica en que los estudiantes fallan en el aprendizaje de las ciencias debido a que poseen poca habilidad para organizar y relacionar conceptos hasta lograr un conocimiento más estructurado del fenómeno en estudio. Por otra parte, los materiales diseñados para facilitar el proceso de instrucción, por lo general, no se diseñan respetando las estructuras cognitivas del sujeto que aprende, lo que puede retrasar el proceso de aprendizaje, limitando la organización y transferencias a nuevos esquemas. Así como lo señaló Ausubel (1960) y luego otros investigadores lo continúan sosteniendo, la adquisición de un conocimiento organizado y/o estructurado depende de dos condiciones: a) de la organización de los conocimientos previos y b) del uso de estrategias que ayuden al aprendiz a mantener una estructura organizada de dichos conocimientos (Jonassen & Grabowski, 1993).

Investigaciones recientes evidencian que el aprendizaje de conceptos y la interrelación de los mismos es un prerequisito importante para lograr de una manera efectiva y eficiente la retención, la comprensión y la habilidad para transferir el conocimiento adquirido a situaciones nuevas (Mintzes, Wandersee & Novak, 2000; Ruiz-Primo et al., 2001). Por lo que aprender estructuras y esquemas complejos requiere que se analicen las severas limitaciones del sistema de procesamiento de información humana. Como bien se señaló antes, la memoria de trabajo tiene severas limitaciones al procesar información, sin embargo, la memoria a largo plazo retiene esquemas cognitivos que varían en su nivel de complejidad y automatización. Por lo que se asume que la experticia emerge de los conocimientos organizados en estos esquemas. Así, los expertos logran usar y manjar mayor número de esquemas organizados al resolver problemas nuevos o transferir el conocimiento a nuevas situaciones; estas investigaciones han traído consecuencias para el diseño y presentación del material de instrucción (Sweller, 1994; Carlson, Chandler & Sweller, 2003; van Merriënboer & Sweller 2010).

Con esta investigación se busca dar respuesta a tres aspectos importantes como son:

- Dar una explicación teórica para establecer cómo la organización de la información contribuye o impide el paso de una simple retención a una aplicación de conceptos en situaciones nuevas (transferencia).
- Determinar cómo las diferencias individuales -estilos cognitivos y los conocimientos previos- que posee el estudiante favorecen el aprendizaje dependiendo de las formas en que se organice y presente la información.
- Proponer el uso de mapas de conceptos como medida alternativa para evaluar el conocimiento estructurado del aprendiz.

3. Metodología

3.1 Diseño de Investigación

Se utilizó un diseño experimental para facilitar la manipulación simultánea de más de dos variables independientes y analizar interacciones complejas con las medidas dependientes objeto de estudio. Se propuso un diseño factorial entre sujetos de 3x2. El Factor A, correspondió al formato de aprendizaje, el cual tiene tres (3) niveles: 1) Texto, 2) Mapa, y 3) combinación Mapa-Texto; el Factor B, correspondió al ambiente de la tarea, el cual tiene dos (2) niveles: 1) Computador y 2) Papel y lápiz.

Variables independientes. La Tabla 1, muestra los factores que conformaron las variables independientes que se estudiaron en la presente investigación. La variable estilos cognitivos fue considerada como una variable interviniente, que pudiera explicar como un sujeto aprende más, cuando su preferencia de aprendizaje corresponde con el tipo de formato dado. Por ejemplo, un sujeto con estilo visual puede aprender más a través de un formato visual, como lo es un mapa de conceptos. La variable estilos cognitivos se midió en dos dimensiones: Verbal, bimodal y visual; y Holístico, intermedio, y analítico.

Otras variables independientes que se consideraron fueron: Nivel de conocimientos previos (altos y bajos), nivel de experiencia en el uso del computador (alto, medio y bajo), variables demográficas, grado de dificultad

para aprender utilizando un formato determinado (texto, mapa o combinación de formatos) y medio al generar un mapa de conceptos (papel-lápiz o computador).

Variables dependientes. Se utilizaron dos variables como medidas dependientes:

1. Ganancia entre el pretest y el postest en términos de transferencias simples y complejasGeneración de un mapa de conceptos. A través del mapa se midieron a) número de proposiciones y b) precisión de la información.

La decisión de usar dos instrumentos de medida como el postest y el mapa generado se implementó con dos propósitos, 1) a fin de comparar si ambos instrumentos arrojan resultados en la misma dirección mostrando consistencia y 2) determinar si la generación de un mapa de conceptos mide conocimientos estructurados.

Tabla 1: Diseño Factorial

Ambiente de la tarea \ Formato de aprendizaje	Texto	Mapa	Mapa-Texto
Computador	24	24	24
Papel y Lápiz	24	24	24

3.2 Población y Muestra

La población objeto de estudio estuvo representada por 300 estudiantes universitarios cursantes del primer año de Psicología, del curso de Psicología General de una universidad estadounidense ubicada al suroeste del país.

Un total de 144 sujetos fueron seleccionados y asignados al azar a cada condición experimental. El número de la muestra se decidió sobre la base del número de grupos que resultó de la multiplicación de los factores (3x2), dando un total de 6 grupos o condiciones, resultado en 24 sujetos en cada grupo, entre otras razones para aumentar el poder estadístico al aumentar el tamaño de la muestra, y por otro lado para garantizar la distribución normal de los datos.

Se procedió al diseño de los instrumentos de medición y se sometieron al proceso de validación de expertos y validación de contenidos antes de someterlos a la prueba piloto. El estudio piloto facilitó la observación de la consistencia interna de los instrumentos. Como resultado se determinó la validez interna de las pruebas pretest-postest (usando el método de validez por constructo) y confiabilidad, utilizando el método de Cronbach Alfa, el cual arrojó un nivel alto de confiabilidad $\alpha = .80$. Los resultados obtenidos del estudio piloto no se incluyeron en los resultados obtenidos en la investigación que se describe a continuación. 3.3 *Instrumentos*

Los instrumentos utilizados en el estudio consistieron en: 1 cuestionario con tres partes: a) identificar datos demográficos, b) escala para identificar actividades y la frecuencia en el uso del computador, y c) preguntas para determinar experiencia en el aprendizaje con mapas y en el uso del software para realizar mapas de conceptos. 1 pretest-postest, ambas con igual contenido y número de preguntas. Está dividido en preguntas para identificar transferencias simples y transferencias complejas. 1 cuestionario con una sola pregunta utilizando una escala tipo Likert del 1 al 7 para identificar grado de dificultad para aprender con el formato dado; 1 cuestionario con una sola pregunta utilizando una escala tipo Likert del 1 al 7 para identificar el grado de dificultad en generar un mapa de conceptos; el test computarizado para analizar los estilos cognitivos (Cognitive Style Analysis –CSA, Riding, 1991; 1998); y 1 mapa criterio. El mapa criterio es el instrumento que se diseñó para comparar y evaluar los mapas generados por los estudiantes. El investigador diseñó el mapa criterio, el cual fué validado por los profesores de la cátedra.

3.4 Materiales de Instrucción

Profesores de la Escuela de Psicología de la universidad estadounidense con más de 10 años dictando el contenido, identificaron un tema complejo del curso Psicología General. De allí surgió el tema “Percepción e Ilusiones Visuales” correspondiente a la unidad número 6 del curso. El investigador diseño ambas versiones – texto y mapa- ambos formatos fueron validados por expertos en el área. El mapa criterio sirvió: como formato de aprendizaje, y como mapa criterio para evaluar los mapas generados por los estudiantes.

El formato *Texto* consistió en dos páginas de contenido sobre percepción e ilusiones visuales. El formato *Mapa de Conceptos* representó los mismos conceptos propuestos en el formato texto, pero a través de relaciones entre conceptos y conexiones llamadas proposiciones. El mapa está compuesto por los siguientes elementos: 33

nodos, 46 líneas de enlace, 11 palabras de enlace, 108 proposiciones, y 2 interconexiones. El formato *Combinado Mapa-Texto* consistió en darle a cada sujeto los dos formatos descritos anteriormente: texto y mapa de conceptos. Estos sujetos pudieron aprender la misma información a través de dos formatos diferentes.

3.4.1. Materiales para el Entrenamiento y Procedimientos

Se diseñó una guía para facilitar el entrenamiento de cómo generar mapas de conceptos utilizando el software Inspiration, versión 6. Esta consistió de 3 páginas, con 6 pasos básicos para generar el mapa. El material utiliza gráficos y vocabulario básico sobre el uso del computador; asimismo, el último paso muestra un ejemplo de mapa generado por un experto. La guía fue diseñada con la ayuda del centro de tecnología y educación de la Escuela de Educación. El experimento se llevó a cabo en un laboratorio de computación con todas las condiciones controladas para el aprendizaje. Se procedió a leer las instrucciones y se asignaron aleatoriamente los sujetos a cada tratamiento (texto, mapa o formato combinado).

4 Análisis de Resultados

4.1. Técnicas de Análisis

Se evaluaron un total de 288 pretest-postests y 144 mapas de conceptos. Quince por ciento (15%) de los protocolos de los pretest-postests y mapas seleccionados al azar fueron evaluados por otro profesor-investigador para determinar nivel de confiabilidad del proceso de corrección. Igualmente se procedió a la corrección de los mapas generados en papel y lápiz y en computador. Se procesaron los datos a través del uso del paquete estadístico SPSS versión 14. Se procedió a probar cada hipótesis planteada utilizando el modelo estadístico, análisis múltiple de covarianza (MANCOVA). También se usaron otros modelos estadísticos como el análisis de varianza (ANOVA) entre sujetos, de una y dos vías y se utilizó la prueba *t* de student (*t*-test).

4.1.1. Escala Utilizada para Evaluar Mapas de Conceptos

Los mapas fueron evaluados siguiendo el mapa criterio, tal y como lo sugieren Ruiz-Primo & Shavelson (1996) y Ruiz-Primo et al., (2001) y usando la escala de evaluación propuesta por Novak & Gowin (1984) con algunas modificaciones.

Escala de medición. Se asignó mayor puntaje a las proposiciones que a los conceptos ya que la explicación de las relaciones está considerada un indicador robusto del entendimiento. Se asignó 3, 2, o 1 punto a cada concepto, dependiendo de su complejidad y ubicación, por ejemplo: se asignó 1 punto a los conceptos correctos pero que no estaban en la ubicación correcta. Se asignó 6, 4, o 2 puntos dependiendo de la complejidad y ubicación de las proposiciones, por ejemplo: se asignó 2 puntos por proposiciones correctas que no estaban en la ubicación correcta. Se asignó 2 puntos por cruce de ideas relacionadas o por ideas integradas.

Asimismo, se evaluaron otros elementos, por ejemplo el número de nodos, líneas de enlace. El beneficio de usar ambos métodos fue que se pudo identificar las proposiciones y la precisión de la información dada.⁵

Resultados

5.1 Evaluación de Asunciones

Fueron examinadas tres asunciones del análisis multivariado, con el objeto de considerar el cumplimiento de los supuestos paramétricos: normalidad, homogeneidad de varianzas e independencia de errores. La normalidad se cumplió observando la distribución de la curva normal de la data. La homogeneidad de varianza se evaluó a través del test de Bartlett-Box, el cual indicó que no hubo violación de esta asunción. Finalmente, se obtuvo a través del test de Durbin-Watson que MANOVA cumplía con la asunción de independencia de error. La evaluación de estos supuestos paramétricos contribuyó a controlar o reducir el error Tipo I, que suele ocurrir cuando hay más de una variable criterio.

Usando el método de la distancia de Cook, se identificó y excluyó a un sujeto que era influyente en la data, es decir que sus datos desviaban considerablemente el comportamiento del grupo. Este sujeto correspondió al grupo que estudió utilizando texto, y se encontró que salió sobresaliente en ambas pruebas, pre y postest y número de proposiciones correctas al generar un mapa. El nivel de alfa utilizado fue igual a .05 ($p<.05$) para todas las pruebas estadísticas.

5.2. Análisis Preliminares. Diferencia entre las Medias del Pretest – Postest

Antes de iniciar las pruebas estadísticas correspondientes a cada pregunta de investigación, se procedió a realizar pruebas preliminares con las cuales se identificaron dos aspectos importantes, el primero relacionado en

la consistencia de los datos obtenidos en las pruebas de pretest – postest. En vista de que hubo diferencias significativas entre las medias del pretest -postest se decidió usar el pretest como variable covariante en las próximas pruebas estadísticas de las preguntas de investigación propuestas en el presente estudio. Otra prueba preliminar realizada consistió en probar la correlación entre los datos obtenidos del postest y los datos obtenidos del número de proposiciones correctas al generar un mapa de conceptos. Se quiso observar si las dos medidas dependientes usadas en el estudio podían utilizarse para medir el aprendizaje de los sujetos. Para expresar el grado de relación existente entre ambos puntajes obtenidos se realizó la prueba de correlación Producto-Momento de Pearson. Con esta prueba se obtuvo que existe una relación positiva y moderada entre ambas medidas.

5.3 Descripción y Análisis de Variables Demográficas.

Las variables demográficas se comportaron de la siguiente manera: en cuanto a los grupos étnicos se observó que el 47% de los sujetos eran Caucásicos, 41% Hispanos, 6% Indígenas- Americanos, 4% Afro-Americanos, 1% Asiáticos, 1% otros. Género: 60% femeninos. 40% masculinos. La edad promedio fue de 22 años.

Se realizó un análisis de MANCOVA, utilizando el pretest como covariante, el cual mostró, según el criterio de Lambda de Wilks, que las variables dependientes combinadas con la variable grupo étnico Wilk $\Lambda=.86$, $F(10, 116)=.87$, $p>.05$, la variable género Wilk $\Lambda=.99$, $F(2, 58)=.016$, $p>.05$ y la variable edad, Wilk $\Lambda=.65$, $F(10, 116)=.70$, $p>.05$, no resultaron significativamente afectadas por el formato de aprendizaje utilizado.

5.4 Experiencia en el Uso del Computador y Mapas de Conceptos.

76% tiene alta experiencia, 23% tiene experiencia promedio en el uso del computador, y 1% tiene baja experiencia; en su mayoría (78%) no tenían experiencia con mapas de conceptos y 92% no tenía experiencia con el software Inspiration.

5.5 Clasificación de Estilos Cognitivos que Caracterizan al Sujeto.

Esta variable se analizó a través del Cognitive Style Analysis (CSA) y se obtuvo que los sujetos se clasificaron en la dimensión analítico-holístico, de la siguiente manera: 41% se caracterizaron con estilo analítico; 31% intermedio; y 28% holístico; y en la dimensión visual-verbal, se observó que el 26% se caracterizaron por poseer un estilo verbal; 30% bimodal; y 44% visual. Una vez descritas las variables demográficas y realizados los análisis preliminares del estudio, se procede a presentar los resultados estadísticos de cada pregunta de investigación que orientaron este estudio.

Pregunta 1: ¿En qué medida el formato de aprendizaje facilita la adquisición de la nueva información?

Un análisis multivariado de covarianza (MANCOVA) se utilizó para determinar la efectividad del formato utilizado durante la actividad de aprendizaje, la cual se midió a través del uso de dos medidas dependientes, el postest y las proposiciones correctas al generar un mapa de conceptos. En el análisis realizado, producto de la combinación de los valores del postest y las proposiciones, se obtuvo que hay un incremento significativo en los conocimientos alcanzados por los sujetos que estudiaron utilizando el formato mapa. La diferencia pretest-postest fue estadísticamente significativa, por lo que se usó el pretest como covariante en el resto de los análisis.

En la Figura 1 se observa que los sujetos que usaron mapas salieron substancialmente mejor en la prueba del postest que aquellos que usaron el formato combinado o el texto. Sin embargo, se observó que no hubo diferencias significativas entre los grupos que usaron mapas o formato combinado en los resultados de las proposiciones.

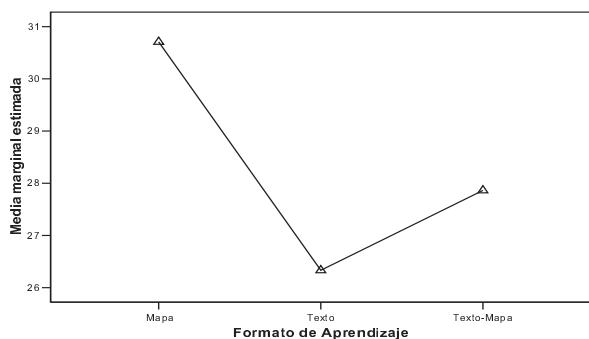


Figura 1. Efecto del formato de aprendizaje en los resultados del postest . N= 143

Pregunta 2. ¿En qué medida influyen los estilos cognitivos en el aprendizaje según el formato de aprendizaje utilizado en la tarea?

El instrumento Cognitive Style Analysis (CSA), utilizado para medir estilos cognitivos midió esta variable en dos dimensiones, la primera estuvo relacionada con la dimensión que ubica a los sujetos en un continuo ‘holístico, intermedio y analítico’. La segunda dimensión, ubica al sujeto en un continuo ‘visual, bimodal y verbal’.

Efecto del Estilo Cognitivo Holístico-Analítico en el Aprendizaje. Se realizó un MANCOVA de medidas repetidas con cada una de las variables dependientes: Postest y Proposiciones. Esto con el fin de identificar algún efecto de la variable estilos cognitivos-dimensión holístico-analítico- en el aprendizaje.

Se encontró que la interacción entre estilo holístico-analítico, formato de aprendizaje y los resultados obtenidos en el postest y proposiciones obtenidas al generar el mapa de conceptos, no fue significativa, Wilk $\Lambda = .98$, $F(8, 266) = .28$, $p > .05$. Sin embargo, se observan tendencias definidas en los gráficos obtenidos del análisis. Se observó que sujetos con estilo cognitivo ‘intermedio’ tienden a ejecutar mejores mapas de conceptos cuando aprenden con un formato combinado, que aquellos caracterizados por estilos holísticos o analíticos. Asimismo, se observa que independientemente del estilo que caracteriza al sujeto, aquellos que utilizaron texto en la actividad de aprendizaje, salieron considerablemente por debajo de la media de aquellos que usaron otros formatos.

Aunque no se observaron diferencias significativas entre la interacción de la variable estilos cognitivos, formato de aprendizaje y las variables dependientes, se logró observar producto del análisis, que independientemente del estilo cognitivo que caracterice al sujeto, el uso del mapa para aprender arrojó resultados positivos en el rendimiento del postest, $F(2,139)=5.09$, $MC = 233.04$, $p<.05$.

Efecto del Estilo Cognitivo Visual-Verbal en el Aprendizaje. Los mismos procedimientos estadísticos realizados con la variable estilos cognitivos, dimensión holístico-analítico, fueron aplicados a la dimensión Visual-Verbal. La prueba ómnibus, usando el criterio de Lambda de Wilks, mostró que las variables dependientes combinadas no resultaron significativamente afectadas por la variable estilos cognitivos en interacción con formatos de aprendizaje. Sin embargo, se observó una tendencia positiva en los sujetos que se caracterizan por el estilo bimodal, es decir que tienden a usar ambas formas de procesamiento del material ya sea visual o verbal.

Pregunta 3. ¿De qué manera influyen los conocimientos previos al aprender a través de un formato determinado -texto, mapa de conceptos o combinación de ambos- en las respuestas del postest que están relacionadas con transferencias complejas?

De un total de 143 sujetos que participaron en el estudio, éstos se dividieron según el resultado de la media del pretest en dos grupos, *bajos* y *altos* conocimientos previos. Primero, se analizaron los sujetos clasificados de bajos conocimientos previos, según la prueba, seguidamente los de alto conocimientos previos. El postest se dividió en dos conjuntos de preguntas relacionadas con transferencias simples y transferencias completas. Las preguntas de transferencias simples correspondieron a las preguntas números 3, 4, 5, 6, 8, 12, y 12b sumando un total de 16 puntos por transferencias simples. Las preguntas de transferencias complejas correspondieron a las preguntas números 1, 7, 9, 10, 11, y 12c, sumando un total de 30 puntos por transferencias complejas.

Bajos Conocimientos Previos en la ejecución de Transferencias Simples y Complejas

El test de ómnibus, usando el criterio de Lambda de Wilks, mostró que los sujetos que poseen bajos conocimientos previos y que usaron el formato de mapa lograron mayor puntaje al realizar transferencias

complejas, Wilk $\Lambda = .90$, $F(4, 142) = 1.98$, $p < .05$. Sin embargo, no se observó ningún efecto del formato en sujetos de bajos conocimientos previos que realizaron transferencias simples.

La Figura 2 muestra los sujetos con bajos conocimientos previos que tienden a disminuir su rendimiento en transferencias complejas cuando usan un texto o formato combinado. Observándose que cuando usan el formato mapa de conceptos ellos tienden a incrementar su rendimiento de manera significativa. Mientras que en la Figura 3, se observó la misma tendencia que en sujetos de bajo conocimientos previos, ambos grupos muestran tendencias positivas en el uso de mapas de conceptos, pero no así con el uso de textos o formatos combinados.

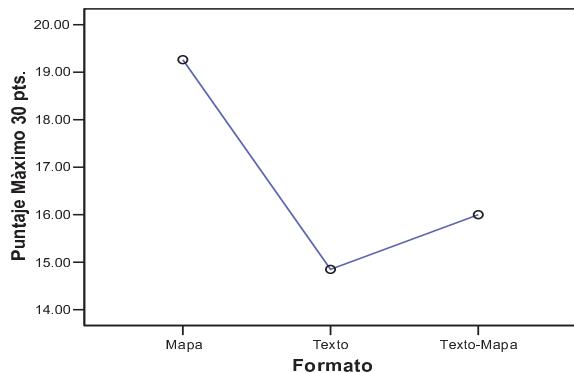


Figura 2. Efecto de bajos conocimientos previos en preguntas de transferencias complejas. N= 76

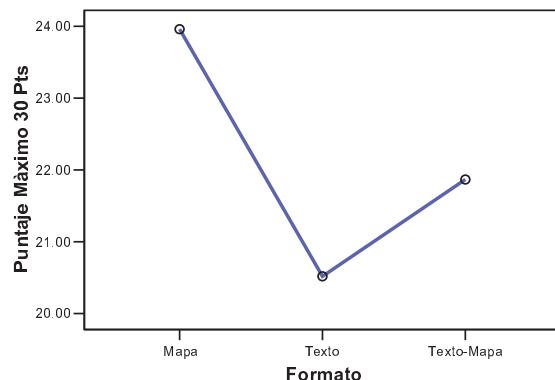


Figura 3. Efectos de altos conocimientos previos en preguntas de transferencias complejas. N= 67

Altos Conocimientos Previos en la ejecución de Transferencias Simples y Complejas. Según el criterio de Lambda de Wilks, se observa que los sujetos que poseen altos conocimientos previos y que usaron el formato de mapa lograron mayor puntaje al realizar transferencias complejas, Wilk $\Lambda = .85$, $F(4, 126) = 2.59$, $p < .05$. Asimismo, no se observó ningún efecto del formato en sujetos con altos conocimientos previos que realizaron transferencias simples.

Pregunta 4. ¿En qué medida la experiencia en el uso del computador facilita la generación de un mapa de conceptos en ambientes computarizados?

El nivel de experiencia en el uso del computador fue subcategorizada en tres niveles: alto, medio y bajo. Se realizó una prueba de ANOVA de dos vías, observándose que el efecto de la variable experiencia en el uso del computador al generar un mapa en el computador, no fue estadísticamente significativo, $F(2, 201) = .286$, $p > .05$. Lo que sugiere que la experiencia en el uso del computador no influyó en el número de proposiciones correctas al generar un mapa de conceptos.

Pregunta 5. ¿En qué medida el medio - computador o papel y lápiz- utilizado para generar un mapa de conceptos influye en el aprendizaje adquirido?

El efecto de la variable ambiente de la tarea (computador – papel y lápiz) no fue estadísticamente significativo al observar los resultados del postest o al generar un mapa de conceptos, Wilk $\Lambda = .97$, $F(2, 140) = 2.06$, $p > .05$.

6. Conclusiones

6.1 Formatos de Aprendizaje

Se aceptó la hipótesis de que los sujetos que usan mapa de conceptos obtienen mayores puntajes al realizar transferencias complejas, que aquellos que usan otros formatos. Las ganancias obtenidas en el postest por los sujetos que usaron mapas, y que superaron inclusive a aquellos que usaron formatos combinados, deja en evidencia que el uso de formatos combinados puede obstaculizar el aprendizaje en sujetos con bajos conocimientos previos (Liu, Lin & Paas, 2014). Se puede inferir que de todos los sujetos que participaron en el estudio, los que más se beneficiaron principalmente del aprendizaje con mapas, fueron los caracterizados por poseer bajos conocimientos previos.

Asimismo, se concluye que tanto el texto como el formato combinado, imponen mayor grado de dificultad al aprender a través de dichos formatos. Sin embargo, los sujetos con altos conocimientos que usaron formatos combinados lograron obtener mayores puntajes al generar un mapa. El generar un mapa o proposiciones, como se llamó en este estudio, facilitó la medición de los conocimientos estructurados, tal y como lo sugieren Ruiz-Primo et al. (1996; 2001) y Jonassen, Beissner, y Yacci, (1993), quienes afirman que la generación de un mapa puede medir con mayor precisión el conocimiento estructurado u organizado que posee el aprendiz sobre un dominio determinado.

Existe extensa evidencia experimental concerniente al papel recíproco jugado por el uso de información visual y verbal en actividades de aprendizaje (Paivio, 1971). Teóricamente se puede explicar por qué los sujetos que usaron el formato combinado pudieron obtener mejores resultados al generar un mapa de conceptos. Una de las distinciones que propone la teoría de código dual (Paivio, 1971), es que los procesos relacionados con el procesamiento visual de imágenes están vinculados funcionalmente con el estímulo o tarea, mientras que los procesos verbales son más independientes de esta dimensión. Congruente con esta propuesta teórica que apoyan los resultados de esta investigación, están los relacionados con el funcionamiento de la memoria de trabajo, específicamente el modelo de procesamiento de información propuesto por Baddeley (1986), quien sostiene que la memoria de trabajo consiste en un sistema de memoria operativa responsable de la retención y el procesamiento de la información.

6.2 Conocimientos Previos

Pudiera inferirse que los estudiantes que no poseen conocimientos suficientemente estructurados en un área de conocimientos dada, el uso del mapas puede ayudarlos a formar esta estructura; mientras que un formato combinado pudo contribuir a dividir su atención y consecuentemente restringir aún más la capacidad de memoria de trabajo, en consecuencia impedir un mejor aprovechamiento de la información. Según Chandler y Sweller (1992) y Mayer y Moreno (1998), ‘el efecto de dividir la atención’ resulta cuando el aprendiz necesita atender simultáneamente a dos o más fuentes de instrucción o actividades. Así, el efecto de los formatos combinados en estudiantes con bajos conocimientos previos, puede causar una división de su atención impidiendo la consolidación de un nuevo esquema y/o la transferencia del conocimiento adquirido al resolver un nuevo problema (Liu & Lin, 2011).

6.3 Estilos Cognitivos

Con respecto a esta variable y su interacción con las medidas dependientes, no se observó ningún efecto, debido a la inconsistencia del instrumento utilizado para medir. Se sugiere seguir explorando su efecto en el aprendizaje, utilizando otros instrumentos que reporten altos niveles de confiabilidad.

7. Limitaciones del Estudio

El instrumento utilizado para medir los estilos cognitivos (CSA) fue una limitación en el estudio. Se observó que el instrumento no fue lo significativamente sensible a las diferencias de estilos cognitivos y su interacción con las medidas dependientes de los estudiantes.

8. Reconocimiento

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APPLICATION OF CONCEPT MAPS FOR CONDUCTING RESEARCH

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Abstract. This literature review focused on how scholars and practitioners have used concept maps for conducting research. The purpose of the use of concept maps for research fell into three main categories: data collection, data analysis, and data presentation. The uses in data collection included participant data generation as well as concept and process gathering. The main themes for uses of concept maps in data analysis were: organizing information from the data collection, quantitative and qualitative coding, and processing and interpreting data to identify linkages, relationships, and gaps. Researchers described using concept maps to present data in more general terms or without explicitly stating the use. Many advantages of concept maps for research were found including the benefit of exploring issues in real time, creating a visual dialogue, and documenting issues quickly. However, the lack of clearly documented steps for integrating concept maps into the research process was noted. Lastly, ideas for further implementation of concept mapping into research and a synthesis of findings through a concept map are given.

Keywords: Concept maps, Research, Data collection, Data analyses, Data presentation

1 Introduction

Concept maps have been used in a variety of ways as a tool for conducting research – from problem formulation and illustration, data collection and organization, to data analysis. As we use concept maps when doing research or working with doctoral students, we decided to conduct a literature review to identify strategies scholars use with concept maps for better conducting our own research and instructing students. Although authors in our literature review operationalized concept maps as a visual organizer in multiple ways, we considered concept maps in the format proposed by Novak and Gowin (1984). The purpose of this paper is to identify and analyze existing literature in which concept maps were utilized as a research tool. By theorizing from the literature and making connections among different approaches that use concept maps, we can broaden our understanding of the application of concept maps in research. We start the paper by presenting the methodology we used for completing the literature review. Next we present our literature review findings beginning with: the most common applications of concept maps in research, uses of concept maps in research methodology, purposes of concept maps for research, advantages and limitations of the use of concept maps for research, and implications of the use of concept maps for research. We conclude our paper with a synthesis of our findings in a graphical representation of our themes through a concept map (Figure 1).

2 Literature Review Methodology

In this literature review of concept maps for research, we confined our search to the use of concept maps in research specifically as a research tool. A search was conducted on a variety of databases including ERIC, EBSCOHost, PsychINFO, ProQuest, and Google Scholar. The search was restricted to the years 1998-2013. The key terms used in the search were “concept map,” “concept mapping,” “research,” “analysis,” “presentation,” “collection,” and “data.” Research studies that looked at concept maps as a learning tool were excluded, as they did not fit our parameters of using concept maps as a research tool. A refined search on these terms produced 2000 hits on EBSCOhost. We narrowed our search to 24 peer-reviewed journal articles, one dissertation, and one published book that met our set of criteria.

Once we identified the publications to review, we developed a matrix for analyzing the literature with the categories to extract from each article: article name, application (data collection, data analysis, data presentation), research methodology (quantitative, qualitative, mixed methods), purpose of use (how concept maps were used), advantages, limitations, and implications (See Table 1). We distributed the articles among the three members of our research team. After reviewing the articles, we completed the matrix, and member checked our findings to verify that we met the set of criteria we established. We then looked for themes and patterns within each category. Our findings are presented based on the categories we established in the matrix and respective themes.

Table 1: Matrix for Analyzing the Literature Review

Article	Application	Research Methodology	Purpose of Use	Advantages	Limitations	Implications

3 Most Common Applications of Concept Maps in Research

Our initial analysis of the publications was based on three main strategies: data collection, data analysis, and data presentation. Of the 24 articles we selected, we found 9 publications that fit within the parameter of concept map application as a tool for data collection (for example, Campbell & Salem, 1999; Wheeldon, 2011), 15 for data analysis (for example, Brightman, 2003; Maxwell, 2013), and 5 for data presentation (for example, Butler-Kisber & Poldma, 2010; Wheeldon, 2010). Many of the publications applied concept maps for data analysis and data collection as part of a process for conducting research (for example, Daley, Cañas, & Stark-Schweitzer, 2007; Morgan, Fellows, & Guevara, 2008). Little was found in publications about the application of concept maps for presentation.

4 Use of Concept Maps in Research Methodology

The majority of the publications indicated the use of concept maps for qualitative research. When used as a part of quantitative research methodology, researchers used mixed methods. Within mixed methods, qualitative methodology was used to collect data and quantitative methodology was used to analyze data. For qualitative research, concept maps were used for different purposes: data collection, data organization, data analysis and interpretation, analysis of participant generated data of experience, or to explain and present a conceptual framework or theory. For quantitative research, concept maps were used to display information, graphically illustrate concepts and connections, and cluster data.

5 Purpose of Use of Concept Maps for Research

We found a variety of purposes for which concept maps have been used for data collection, data analysis, and data presentation. We analyzed the three concept map application categories and present them next based on themes within each category.

5.1 Use of Concept Maps for Data Collection

Concept maps have been used for data collection mostly for (1) participant data generation through recall, reflection deconstruction, and organization of data or (2) concepts and processes gathering, refining, or honing.

5.1.1 Participant Data Generation

Wheeldon (2011) showed how participant generated data of experiences using maps helped to reach greater recall. Brightman's (2003) methods for qualitative research used the interviewer as facilitator and data gatherer through concept maps. This method allowed for concept building at the time of data gathering. Likewise Meagher-Stewart, Solberg, Warner, MacDonald, McPherson, and Seaman (2012) used participant generated concept maps, but they were used for integrating and displaying information, deconstructing personal experiences, and identifying key concepts. In this case, concept maps were created in groups and permitted meaningful ways for participants to clarify the connections between people and concepts and enabled consensus building.

Morgan and Guevara (2008) also used participant generated concept maps, but with groups to guide participants in individual interviews or focus groups through the generation of the relationships among a set of key concepts. In this instance, this method provided an opportunity to "give voice" to participants and offered participant ascribed insights into the meaning of their experiences. Campbell and Salem (1999) used concept maps to bring people together to generate ideas. This method gave voice to women and included "the direct expression of participants' voices with minimal interpretation by researchers" (p. 85).

5.1.2 Concept and Process Gathering

We found unique ways for collecting data through the use of concept maps: to reveal conceptual typologies, to generate a literature review, to refine and hone data, and to formulate and illustrate the research problem.

Hay and Kinchin (2006) used concept maps to explore and explain knowledge, the understanding of a topic, and to reveal existing knowledge. Rather than following a usual approach to data collection, this method allowed for the revelation of the structure, organization, and elaboration of concept understanding. Another approach to data collection was used by Burke, O'Campo, Peak, Gielen, and Trochim (2005) in a participatory qualitative research. In this case, a conceptual framework for how a group viewed a particular topic or aspect of a topic was used. This method allowed for the collection of a wide range of participant-generated ideas.

Wheeldon and Faubert (2009) also used concept maps as a data collection tool and an alternate means of communicating (not just the verbal or written narrative). The concept maps gave a “snapshot” of perception. In this case, concept maps allowed for the refining and honing of additional data collection processes.

Pokharel (2009) used concept maps for a conceptualization purpose as a way to formulate and illustrate the problem. This method provided a process for helping people think more effectively as a group without losing their individuality. In addition, the methods provided a process for groups to capture complex ideas without trivializing them or losing detail. Researchers could also develop and detail ideas for their studies. As a process, it provided an objective record of what was done in each step and researchers could be more publicly accountable.

5.2 Use of Concept Maps for Data Analysis

Concept maps have been used for data analysis primarily for (1) organizing information from data collection; (2) quantitative and qualitative data coding; and (3) processing and interpreting data in order to see linkages, relationships, and gaps. Although there was overlap in categories, the resources have been organized into the main foci. Because the data analysis process is not a linear one, several authors commented on the interconnection between the collection and the analysis processes (Burke et al., 2005; Campbell & Salem, 1999; Meagher-Stewart et al., 2012; Morgan & Guevara, 2008).

5.2.1 Organizing Information from Data Collection

Researchers have found that concept maps can be an effective way to organize information. Carnot (2006) suggested that concept mapping could be an effective tool for organizing large literature reviews. In particular, she argued researchers can find major categories and “cross-cutting” topics in order to pull together themes and visualize complex connections (Carnot, 2006). Cmap Tools as an online computer software can facilitate this process (Daley, Canas, & Stark Schweitzer, 2007). Through the organization of information with Cmap Tools, researchers may be able to see interrelationships of multiple themes in the literature.

Richardson (2007) also addressed concept mapping to organize data from literature reviews. Richardson presented the development of a software for computer science articles that automatically generates concept maps to supplement abstracts of electronic theses and dissertations. The software allowed for a more detailed description of the abstract and allowed the researcher to better organize information.

Daley (2004) and Brightman (2003) suggested that creating a concept map of participant interviews can help the researcher organize data by reducing the volume of research documents. The linkages displayed in the concept mapping document then can be used for further data analysis.

5.2.2 Quantitative and Qualitative Coding

Concept maps can facilitate quantitative and qualitative coding. Jackson and Trochim (2002) suggested that using concept maps for a quantitative analysis of qualitative data, such as coding open-ended survey questions, might provide greater reliability over forced computer categorization of results. Statistical concept mapping that infuses researcher judgment might create a more contextualized interpretation of data.

Burke et al. (2005) also discussed the use of computer concept mapping software to code data. They used concept mapping software to facilitate the coding of data gathered in a public health setting. The software was used to facilitate the production of illustrative cluster maps, which depicted the relationships between concepts described as the clustering ideas. In addition, Trochim (2006) used computer supported multidimensional

scaling and cluster analysis in order to code and analyze the qualitative input from all research study participants. Trochim and Kane (2005) combined group processes with a sequence of multivariate statistical analyses to construct maps as a way of coding for further action planning and program development in health care.

The generation of researcher developed concept maps of interviews (Daley, 2004) can also facilitate the coding of data. Daley stated that the initial sorting of concepts presented in interviews puts order on as well as begins to code the data. This process also provides initial researcher conceptual understanding of interviews, which are important inputs into the data coding process (Brightman, 2003).

5.2.3 Processing and Interpreting Data to See Linkages, Relationships, and Gaps

Concept maps can enhance the processing and interpreting of data. Kinchin and Streatfield (2010) and Daley (2004) suggested that using concept maps to analyze interviews can be helpful. Concept maps also can be used to examine data saturation and improve structure of subsequent interviews (Kinchin & Streatfield, 2010). Daley stated that researcher constructed concept maps of the interview can be used to help the researcher analyze themes and interconnections.

Brightman (2003) explored the importance of the role of concept maps in investigating the researcher's perspective in relationship to the participant's perspective. Researcher generated concept maps at the time of data gathering not only help organize the data, the maps can also provide real time analysis of exploring understanding and start the beginning of the data analysis process. Rather than just mapping the interview, Brightman discussed concept mapping of researcher ideas in relationship to the interview as an important piece of meaning making for the researcher.

According to Morgan and Guevara (2008), concept maps produced by participants can provide an important piece of analysis when comparing the maps generated by two different groups of participants. These maps allowed the researcher to see relationships among a set of key concepts and can be an input into decision-making.

Campbell and Salem (1999) used concept mapping to collect data as well as for the analysis of data. Within action research and feminist research constructs, participant input on the concept maps constructed, brought people together for joint researcher – participant interpretation of the data (Campbell & Salem, 1999). In this case, the interpretation directly provided input into how community systems offer better support to rape victims. In a related approach, Meagher-Stewart et al. (2012) also collected and analyzed data using concept maps in a community and public health setting. In studies incorporating participants in the generation of concept maps and the analysis of concept maps, the participants as groups and the researcher teams collaboratively were able to clarify the connections between concepts and interpret data. Participatory research, such as the work of Burke et al. (2005) in public health, allowed for the qualitative analysis of themes with participants and then the quantitative analysis of themes using software solely done by the researchers.

For the instructor, concept maps can help the researcher evaluate learning (Daley, Canas, & Stark-Schweizer, 2007). The concept maps generated by students can help the instructor evaluate how students construct complex relationships between ideas and how the students analyze their own experiences and link it to new learning. Lastly, concept maps can help researchers with theory development (Maxwell, 2013). Through concept map construction, researchers can visibly see an abstract framework to create, develop, or clarify theory. The process can help the researcher understand the implications of theory, its limitations, and its relevance for a study. In experiential research, Butler-Kisber and Poldoma (2010) used concept maps to interpret data in collaborative research projects. These maps allowed for a visual dialogue among researchers and the processing of information and data in a way in which issues could be documented quickly.

5.3 Use of Concept Maps for Data Presentation

In the final step of research, concept maps can also be used to present findings in a visual manner (Daley, 2004). In her article, Morrison (2006), used concept maps to visually represent her ideas and theories. Several authors used concept maps within articles to present their findings. For example, Campbell and Salem (1999) presented a final concept map for improving the community response to rape as a visual presentation for the reader. Wheeldon (2010) used concept maps to articulate the construction and scoring process to the reader. Butler-Kisber and Poldoma (2010) used participant hand-drawn and computer generated concept maps to present findings. Researcher synthesized and participant generated concept maps were integrated in these articles to

help the reader make connections through a visual approach. As researchers, we have used concept maps to present findings during paper and poster presentations at conferences, to display findings within research articles, to display a framework or theory, to present a visual of a process in a paper, and to compare findings through visuals. Researchers often used concept maps to present their research and findings, but they did not articulate this use as part of their research process. Additional research is needed to thoroughly examine the literature for specific ways in which concept maps are being utilized to present research data.

6 Advantages and Limitations of the Use of Concept Maps for Research

Based on our analysis of the publications found in our literature review, it was evident that there were many advantages of using concept maps as a tool to effectively conduct research as well as limitations. One major limitation is the complexity of the use of concept maps (Carnot, 2006; Trochim & Kane, 2005; Wheeldon, 2011). Butler-Kisber and Poldma (2010) proposed that concept maps can help situate the exploration in real time, create a visual dialogue, and document issues quickly. However, they have noted the lack of clearly documented steps integrating concept mapping into the research process, which can create challenges. For example, refining maps can change previous interpretations of data and if researchers do not have a process for documenting the changes in meaning, one can lose a documentation of the data analysis process.

Jackson and Trochim (2002) argued that concept maps provide greater reliability and validity over word-based and code-based methods when analyzing open-ended survey questions. Yet, the amount of data may overwhelm those sorting the data. Depending on the types of open-ended questions and answers, it might be difficult to code data. Wheeldon and Faubert (2009) found that the use of concept maps provided an alternate means of communication, but questions about how to treat a map that did not conform to the “concept map” definition were a challenge when collecting data.

When it comes to organizing information, Carnot (2006) thought it was beneficial in exploring ideas, conducting comprehensive literature reviews, describing key concepts and task in the subdomain, and describing relevant theory. However, the complexity of the mapping process might distract from higher order thinking for non-proficient users. Another limitation they found was when translating the map to the written form; it was important to do it carefully. Otherwise, the meaning can be lost.

Kinchin, Streatfield, and Hay (2010) found the use of concept maps as interview prompts to be beneficial to check data saturation, present data, and analyze the structure of interviews. However, the process was difficult if the interview was not exploring concepts or relationships or if the interviewee was unable to articulate the relationships. One limitation was if the respondent misrepresented relationships or if the interviewer did not fully understand the context of the participant. Another limitation was if the interview had a prescriptive interview process.

Wheeldon (2010) considered concept mapping as an important strategy for data collection in mixed methods designs. One limitation can be participant resistance because it can alienate certain populations. Another limitation is the difficulty in reading and interpreting concept maps. In addition, validity and reliability can be a problem because concept maps may not be repeatable.

Campbell and Salem (1999) used concept maps in their public health and feminist research through mixed methods. They said that concept maps gave voice to women and brought people together to generate and interpret ideas. For them, the researcher needed to be careful that other issues were not overlooked because of the researcher’s agenda, hierarchy, and focus. They suggest being careful selecting the sample and avoid having only similarly minded people in the study.

Three major interconnected limitations of concept mapping emerged from the literature: time consuming, demanding, and resource intensive. Though Meagher-Stewart et al. (2012) considered using concept maps meaningful for consensus building, they also thought they were time consuming. Hay and Kinchin (2006) identified the use of concepts as a demanding activity and inhibiting elaboration and change. Burke et al. (2005) considered concept maps resource intensive and time consuming when using software. They suggested that a researcher needs some specialized knowledge to be more efficient in the task.

When Maxwell (2013) used concept maps to explain a conceptual framework or theory, he said it helped pull together and make visible what the implicit theory was, or clarified an existing theory. In other words, it assisted in developing theory. One of the limitations of concept mapping was that it did not automatically create

a paper trail of the attempts. A trail could have helped understand how theory had changed and avoid repeating the same mistakes.

7 Implications of the Use of Concept Maps for Research

The literature review highlighted a variety of ways in which concept maps are being utilized in research. Researchers have used concept maps as a data collection tool. Wheeldon and Faubert (2009) found that using visual representations enabled participants to recall experiences in more depth and detail. Concept maps also provide an opportunity for participants to “give voice” to their experiences and offer insights into the meaning that participants ascribe to these experiences (Morgan, Fellows, & Guevara, 2008).

Concept maps are especially useful in data gathering from groups as it helps people think more effectively as a group without losing their individuality and it enables groups to capture complex ideas without trivializing them or losing detail (Pokharel, 2009). Campbell and Salem (1999) and Trochim and Kane (2005) utilized concept maps in a group setting to gather and organize the collective wisdom of the participants. The process allowed for the collection of a wide range of participant generated ideas (Burke et al., 2005) and using concept maps facilitated a participatory method of developing theory (Meagher-Stewart et al., 2012).

Researchers also use concept maps as a graphical tool in textual coding and interview analysis. Concept maps help researchers graphically illustrate concepts and connections identified by their study participants (Butler-Kisber & Poldma, 2010; Morrison, 2006). Since concept maps are not inherently goal or action oriented, they allow for free expression of links between concepts and the repetition of ideas by participants and can be seen as meaningful in itself (Brightman, 2003). Researchers also are able to provide summaries of their interviews through concept maps (Kinchin, Streatfield, & Hay, 2010), which help them condense data in a meaningful way without loss of essential information (Daley, 2004). In addition, concept maps provide a way for researchers to organize and synthesize large domains of information (Carnot, 2006; Richardson, 2007) such as in literature reviews.

Concept maps also have been used to understand the research process and help the researcher analyze data to identify major issues and categories of research; to look for “cross-cutting” topics and issues that were relevant across domains; and, make connections thereby leading to the identification of themes within the research study (Butler-Kisber & Poldma, 2010; Carnot, 2006; Daley, 2004). Like memos, concept maps are a way of “thinking on paper”; they can help see unexpected connections, or to identify holes or contradictions in the theory and figure out ways to resolve these (Maxwell, 2013).

This literature review highlighted the dearth of articles on using concept maps as a presentation tool in research. While researchers use concept maps in conference presentations, these concept maps are not represented in their published articles. Further research could consider the effectiveness of concept maps as a research findings presentation tool. In addition, the barriers that researchers face in using concept maps as a presentation tool can also be explored.

8 Conclusions

Concept mapping provides a tool for meaning making. Researchers can document and synthesize ideas to drive the analysis and the visual process allows for new ideas to emerge. Concept maps allow for the refining and honing of data collection processes from both individuals and groups. They facilitate meaningful data reduction, data display, and conclusion drawing. Concept maps offer the greatest flexibility in terms of expressing relationships between ideas, which lead to developing theory, and making the theory more explicit. It is also an effective tool for presenting research findings. The application categories of data collection, data analysis, and data presentation are interconnected and Figure 1 displays these connections and cross-links.

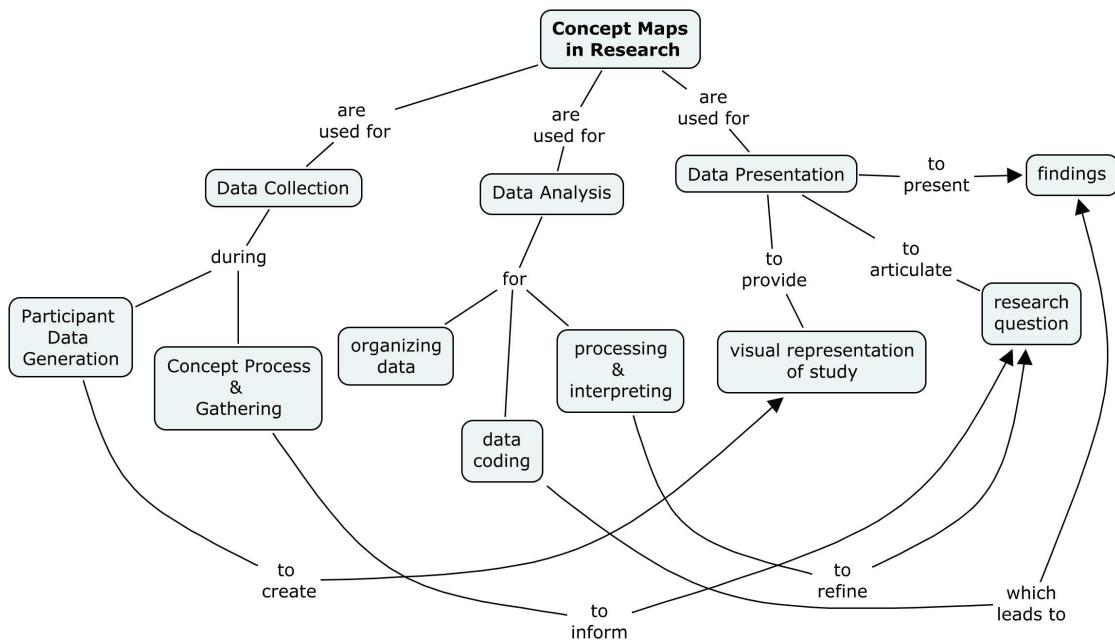


Figure 1: Use of Concept Map for Research

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ASSESSING STUDENTS' INTERDISCIPLINARY APPROACH WITH CONCEPT MAPPING

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Abstract: it is common for several curricula to teach subjects in separated disciplines. Some of the researches have pointed out, that disciplinary learning is not constantly effective due to students' weak ability to create connections between different concepts or topics and because they often do not see the value in what they have learnt. To prevent this from happening, interdisciplinary learning is becoming more and more popular. Interdisciplinary means here that two or more academic disciplines are combined by projects, researchers special subjects etc.. In many countries the topics of natural science (biology, chemistry, physics and geography) subjects are taught separately. Often different teachers teach these subjects. One of the teachers' aims is to develop students' scientific literacy skills on knowledge and understanding of scientific concepts and processes required for personal decision-making, interest for science etc. Researchers have understood that flexible assessing instruments are needed for examining interdisciplinarity. This study focuses on: how to measure students' interdisciplinary approach with concept mapping; what are the measures of concept maps that are important in assessing students' interdisciplinary approach; and how can students create interdisciplinary concept maps? This research focuses on 343 students who combined a focus question based concept map with 30 given concepts. Concepts of the concept maps were separated into four categories: biology, chemistry, physics and everyday life. Analysis pointed out that students created most propositions between concepts from everyday life and within one discipline. It means, students created on average three times more connections between concepts from the same category, than between different categories. Based on the definition of scientific literacy it could be said that the level of scientific literacy is not high for those students, because they are not able to use subject based concepts in different conditions and connect concepts from different categories with one another.

Keywords: interdisciplinary learning, concept mapping, meaningful learning, scientific literacy

1 Introduction

When researching the traditional curricula of different countries, one could notice, that often disciplines are separated from one another and taught by different teachers. It is said that such learning lessens students' learning motivation and entire understanding of the specific topic. As a result, students are not interested in the discipline in the future and do not choose their profession from the unpleasant field. To avoid such outcome, interdisciplinary learning should be used more at schools (in lessons, special projects etc.). Interdisciplinary learning helps to eliminate the fragmentation of isolated skills. It gives students the opportunity to understand a particular theme from different angles and to reach higher scientific literacy skills. It is demonstrated that interdisciplinary teaching can increase students' motivation towards learning as well as raise their level of active engagement. (Ivanitskaya et al 2002; Dillon 2008)

This study introduces the results of a research, where interdisciplinarity was assessed using concept mapping method. The results pointed out that students are not able to associate concepts from different disciplines properly. Research questions were as follows: How to measure students' interdisciplinary approach with concept mapping? What are the measures of concept maps that are important in assessing students' interdisciplinary approach? How can students create interdisciplinary concept maps?

2 Theoretical background

2.1 Cognitive skills

How and when learning appears is the principle question of teaching and learning. According to cognitive psychology, understanding is a mental process of perceiving and knowing. Some compounds of cognitive learning are: reasoning, abstract thinking, decision-making and problem solving. In cognitive learning process, the individual learns by listening, watching, reading or experiencing some stimuli. This input is processed by the brain and noted later. Students, who have learnt cognitively, are able to integrate new information, can explain new knowledge in their own words and know how the studied material fits into other things that they already know (Klassen, 2006). Novak (2010) writes that cognitive learning is the acquisition of knowledge. Cognitive learning establishes some kind of meaning of the concept. Meaning is not an absolute term, but relative. Wong (2012) generalized, that meaning comes from the combination of knowledge learned, feelings felt and actions taken during learning process. That is why meaning is different for every individual. Interplay between new and prior knowledge creates meaning.

2.2 Meaningful learning

Meaningful learning is said to be an important educational purpose. It occurs when students create their knowledge. Cognitive processes are needed for successful problem solving. (Mayer, 2002) Meaningful learning leads to the changes in learners' cognitive structure, so they think more about the idea behind the expressions rather than definition. Interrelated ideas form several networks. (Wong, 2012) According to the Ausubel assimilation theory, three conditions are needed for meaningful learning: 1) students should have relevant prior knowledge; 2) learning materials should be meaningful; 3) learners should want to learn meaningfully. (Novak, 2010; Emenike et al., 2011). In theory, meaningful learning should occur, when above discussed conditions are met. Usually meaningful learning does not appear in every phase of learning, but it gives the opportunity to understand daily surrounding processes and to reach higher scientific literacy skills.

2.3 Scientific literacy

It has been ascertained that individuals have some level of scientific literacy skills. There are several different definitions for scientific literacy. According to the *National Science Education Standards* (NSES), the student, who has scientific literacy skills, is able to:

- 1) ask, find, or determine answers to questions derived from curiosity about everyday experiences;
- 2) describe, explain, and predict natural phenomena;
- 3) read with understanding articles about science in the popular press and to engage in social conversation about the validity of the conclusions;
- 4) identify scientific issues underlying national and local decisions and express positions that are scientifically and technologically informed;
- 5) evaluate the quality of scientific information;
- 6) pose and evaluate arguments based on evidence and to apply conclusions from such arguments appropriately.

The definition for scientific literacy by Holbrook & Rannikmäe (2009) is: developing an ability to creatively utilize appropriate evidence-based scientific knowledge and skills, particularly with relevance for everyday life and a career, in solving personally challenging yet meaningful scientific problems as well as making responsible decisions. Evaluating and developing scientific literacy needs flexible assessing and studying instruments and interdisciplinary teaching which considers students' cognitive skills. There are different levels of scientific literacy like nominal, functional, conceptual, procedural or structural and multidimensional, that assess students' ability to understand and use discipline based terms, principles and theories in everyday life and create connections between different disciplines. (Bybee 1997; Biological Sciences Curriculum Study (BSCS), 1993)

2.4 Interdisciplinary teaching approach

Dillon (2008) wrote (p. 256): "Disciplines have been defined as bodies of knowledge that have been structured culturally and which can be acquired, practised, and advanced through the act of creating" (Li & Gardner, 1993).

Interdisciplinary teaching means teaching a unit across different curricular disciplines. In 1997, Nicolescu defines interdisciplinarity as the transfer of methods from one discipline to another. Interdisciplinarity points out the overflow of disciplinary boundaries but their goals remain limited to the framework of disciplinary research (Dillon, 2008). There are several different models for describing interdisciplinarity. Moran (2002) has pointed out, that interdisciplinary learning includes a valuable degree of flexibility, meaning any form of dialogue between two or more disciplines, but expecting it to be transformative, producing new forms of knowledge (Dillon, 2008). Several authors have described learning outcomes of the interdisciplinary approach. Ivanitskaya and her research team (2002) made a summary of the main statements. Outcomes of interdisciplinary learning are: extending the development or enhancement of cognitive skills; motivating students for deep learning (higher-order thinking); developing critical thinking; knowing when and how to use different learning strategies; knowing how to plan, monitor, and control learning; knowing how to transfer learning skills acquired in the classroom to other contexts and enabling students to expand the range and meaning of their existing knowledge.

Both- scientific literacy and interdisciplinary learning- emphasise, that learning should be meaningful and students should be able to use the knowledge learnt in everyday life and in differently separated disciplines. There are difficulties in examining interdisciplinary knowledge with ordinary assessing methods. Schaal et al (2010, p 341) made a conclusion based on several researches: „When assessing learning in complex

interdisciplinary knowledge domains, traditional tests often fail, especially when specific proficiencies require a foundation of advanced knowledge". For evaluating interdisciplinary learning we need a flexible assessing instrument that considers students' cognitive skills. Borrego with his research team (2009) made a conclusion (p. 5): "To address the gap in assessment tools for interdisciplinary learning and collaboration, we argue that concept maps are an appropriate method of assessing the integration of content knowledge from various disciplines into a coherent picture." Therefore it could be concluded that interdisciplinary learning should develop students' meaningful learning and scientific literacy skills and could be assessed with concept mapping method.

2.5 Concept mapping

Joseph Novak and his research team developed the concept mapping method in the 1970s. This method bases on the meaningful learning theory of Ausubel (1968). Concept mapping suggests that connections could be created between the prior learning and new learning. These connections could be expressed by means of a graphical structure, usually called a concept map. A concept map links new concepts, with prior concepts with lines, labelled as proposition (Novak, 2010; Kinchin 2011). Concept map is a collection of propositions (one proposition consists of 2 concepts and we could "read" them as a sentence) and it declares personal understanding. In this research a special computer program called IHMCmap Tools was used for creating concept maps. The main purpose of concept mapping is to facilitate and assess meaningful learning.

2.5.1 Assessing with concept mapping

Concept maps can be used in school learning process and as an assessment tool, giving a better overview of the student's mental processes and the structure of their knowledge than any other assessment tools. A well-designed concept map test should be able to distinguish between knowledge that has been learned by rote memorization and knowledge that is integrated with related conceptions. (Novak, 2010) There are several different possibilities to assess concept maps. This study focuses on quantitative and qualitative assessment. Quantitative assessment means that numerical scores for a concept map are calculated. These measures should reflect students' understanding of a particular domain. (Keppens, 2007) That information gives the opportunity to analyse the structure of the concept map. A special analysing program CmapAnalysis (Cañas et al 2010) is developed for analysing different parameters in concept maps made with IHMCmap Tools program. These measures are also analysable in MS Excel. This research is looking for the values of:

- a) proposition count (the number of propositions ("sentences") in the concept map);
- b) branch point count (the total number of concepts and linking phrases that have at least one incoming connection and more than one outgoing connection);
- c) orphan count (the number of concepts in the map that have no connections);
- d) intra-cluster proposition count ("sentence", that is created from concepts from the same cluster (discipline));
- e) inter-cluster proposition count ("sentence", that is created from concepts between different clusters (disciplines)).

Kinchin, Hay, and Adams (2000) developed qualitative schemes for assessing concept maps fast and easy. These schemes do not assess the correctness of a map, instead of that they observe the level of complexity by describing cards shapes. They pointed out three categories of maps: spokes (one hierarchy level- shows little complexity and overview); chains (consist of many levels but these are often unclear; links between different levels are missing) and networks (several recognisable levels; this type is the indicator for meaningful learning sequence). (Kinchin, 2011). Schaal et al (2010, p 349) wrote: „However, most important is the innovative possibility to get insights into structural aspects of knowledge and the linkage of concepts. Nevertheless, concept map assessment still is not a common tool in the science education community and more experience is needed.“ Klassen (2006) made the same conclusion in his research. In this study new possibilities on how to assess interdisciplinary approach with concept mapping are looked for.

3 Methodology

This study focused on students (N=343) aged sixteen to seventeen, from 46 different Estonian high schools, who were examined with focus question biased and given concept mapping method. Each of them had to create a certain focus question (instant cold pack- is it only a chemistry?) based concept map with 30 given concepts. Given concepts were from different fields: instant cold pack, first aid, exothermic reaction, energy transfer, pain, bloodstream, cure, friction, edema, risk, nerve impulse, dislocation, water, solvation, endothermic reaction, salt, equilibrium of chemical reaction, tumour, absorption, ethics, health, capillary, freezing temperature, the law of

conservation of energy, safety, melting, speed of chemical reaction, lymphatic, pressure, pH, mole. The aim of the study was to examine the interdisciplinary approach of students. The design of the study is illustrated in Figure 1.

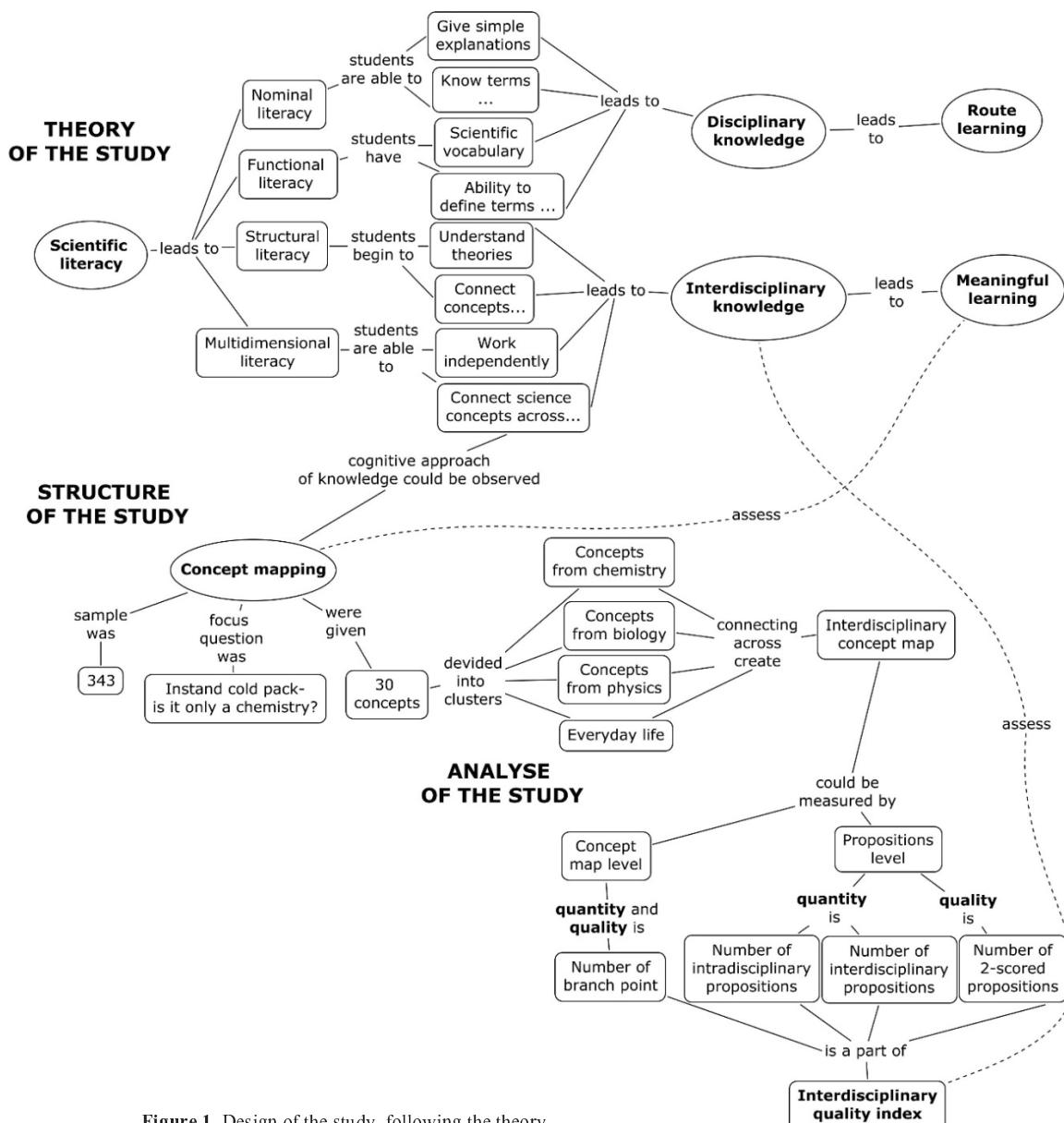


Figure 1. Design of the study, following the theory.

3.1 Data analysis and the results of the study

Data analyses consisted of several different stages. The three stages of the analysis are described below using figure 2.

Firstly, two experts assessed the quality of propositions manually using MS Excel. Marks were given from 2 to 0 (2- very good subject based proposition; 1- correct ordinary daily used proposition or subject based proposition with some questionability; 0-wrong or grabbed proposition).

Secondly, 85 experts, whom were teachers from grammar school ($N=14$), students from Tallinn University ($N=9$) and students from grammar school ($N=62$), distributed the concepts into clusters. It was interesting to note that concepts were distributed by experts mainly by the disciplines, where they are taught and not by the content of the concept. For example dissolution is a concept that describes physical process, but it is taught in chemistry lessons and 94,5% of the experts noted that it is a concept of chemistry.

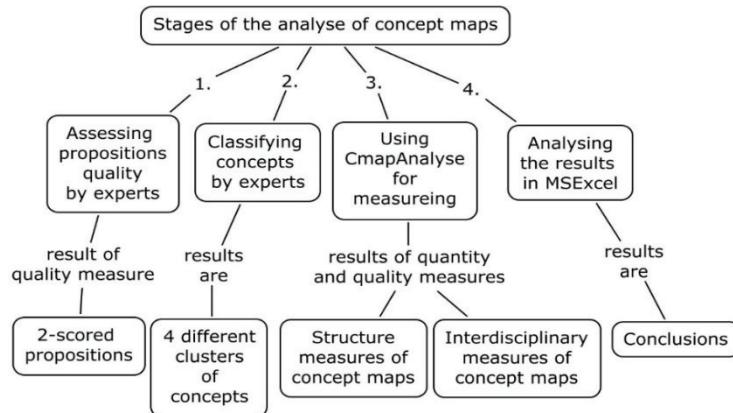


Figure 2. Stages of data analyse of the study

We calculated the possibility to create inter-cluster and intra-cluster propositions. Intra-clusters propositions creating ability is calculated by formula: $C_n^m = \frac{n!}{m!(n-m)!}$; inter-clusters propositions creating ability is calculated as multiply of clusters concepts count.

Thirdly, after using the program CmapAnalysis, several numerical data was received. The aim was to calculate in which cluster (one discipline based or different disciplines based) students created the most propositions from possible proposition ratio. It occurred that students created the highest number of propositions in clusters of one discipline and preferred to compose propositions between everyday used concepts (15,5% of possible propositions). The lowest number of propositions was in the cluster, where concepts from physics and everyday life were presented together (0,5% from possible propositions). It became obvious that students preferred to create one discipline centred propositions for two disciplines or one discipline and everyday used concepts centred propositions.

Next, based on the results, the number of interdisciplinary propositions students had made per concept maps was under study. The authors supposed that interdisciplinarity could have been measured by counting interdisciplinary propositions. The analysis pointed out that only a few students (1,7%) created over 20 interdisciplinary propositions per concept map; 20,5% created 0-5 interdisciplinary propositions; the highest percentage of students (36,7%) created 6-10 interdisciplinary concepts per concept map. While looking at the designs of concept maps, we discovered that although the number of interdisciplinary propositions was high, the concept maps actually did not show students' ability to connect concepts meaningfully from different disciplines so that a highly structured concept map had been created. Many of the concept maps marked as highly interdisciplinary were actually structured as a "star" (or spoke) as there was only one centred concept (as illustrated in Figure 3). Some of the highly scored concept maps were chain type and also did not point out the multidimensional literacy or meaningful learning ability. Some of the concept maps marked as averagely interdisciplinary pointed out that students had connected concepts as groups from different disciplines (as illustrated in Figure 5) or had created really poor concept maps. The number of interdisciplinary proposition count did not point out interdisciplinary concept maps with scientific literacy and meaningful learning ability approach. It was concluded that such measure does not reveal the best interdisciplinary concept maps. Supposedly the reason is that neither the branching of the concept maps nor the quality of propositions was taken in account. The interdisciplinary proposition count: quantity of interdisciplinary concept maps pointed out maps, where many interdisciplinary propositions had been made, but concept map itself was not always highly valued. One of the aims was to find out what components give the best information about the most interdisciplinary concept map structure.

The concept map in figure 3 is "star" shaped, there are a few meaningful connections between concepts; no branch points neither orphans. Interdisciplinary propositions are pointed out with dotted lines. That concept map reflects that student is able to create propositions from concepts of different clusters, but there are no connections of them and this concept map does not express high interdisciplinary nor multidimensional literacy approach. Structure of the concept map is not network and so it does not reflect meaningfully learnt knowledge.

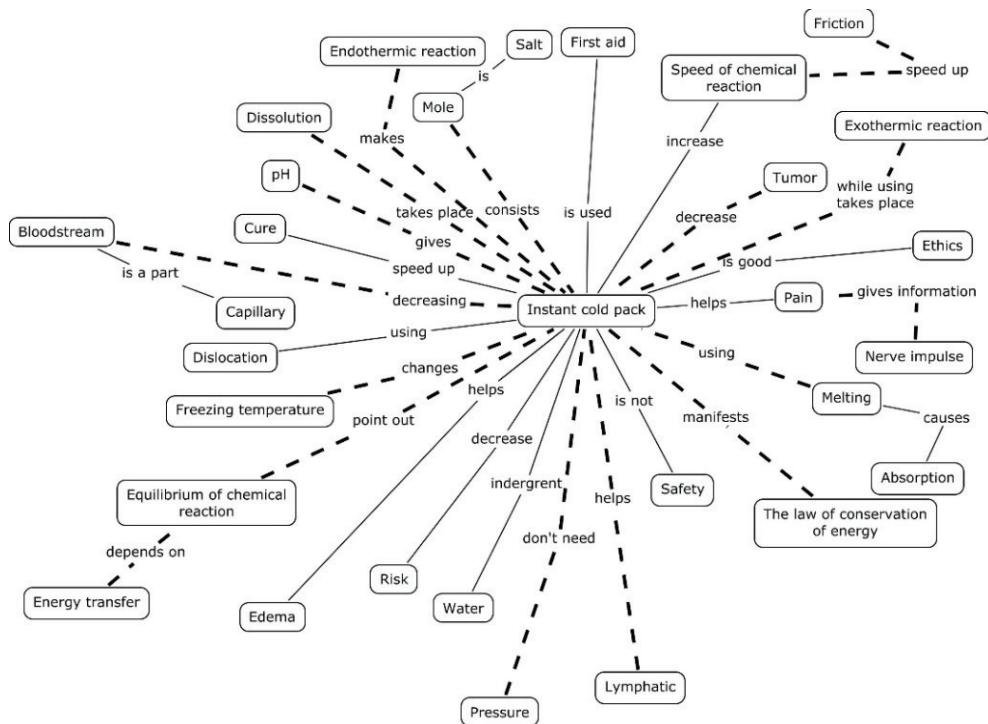


Figure 3. A concept map with high interdisciplinary proposition count (15).

Finally, inter-cluster proposition count was divided with intra-cluster proposition count for eliminating “stars” with high interdisciplinary proposition count. However, this step also did not bring out the most interdisciplinary concept map. Thereafter the quality of interdisciplinary concept map was calculated. At first, the correlation between interdisciplinary proposition count and other quantitative and qualitative measures of concept maps was studied. Correlations occurred between branch points of concept maps ($r=0,67$), orphan count ($r=-0,65$) and experts marked 2-scored propositions ($r= 0,61$)- these measures correlated the most. The most interdisciplinary concept map was found, when the results of measures of concept map (branch point count- it is quantity and quality of concept maps; 2-scored proposition count- describes the quality of propositions) were added. The equation, that describes the quality and quantity of interdisciplinary concept map, is given in Figure 4. One could compare these measures, because they are countable and we optimized each of them to one by the highest result of the sample. There are two examples (Figure 5 and Figure 6) of concept maps and the interdisciplinary index of them.

$$\text{interdisciplinarity index} = \frac{\frac{\sum \text{interdiscipl. propositions}}{\sum \text{intradiscipl. propositions}}}{\frac{\text{Max}_{\text{interdiscipl. propositions}}}{\text{intradiscipl. propositions}}} + \frac{\sum \text{branch points}}{\sum \text{branch points}} + \frac{\sum \text{2-scored propositions}}{\sum \text{2-scored propositions}}$$

Figure 4. Formula for calculating interdisciplinarity index.

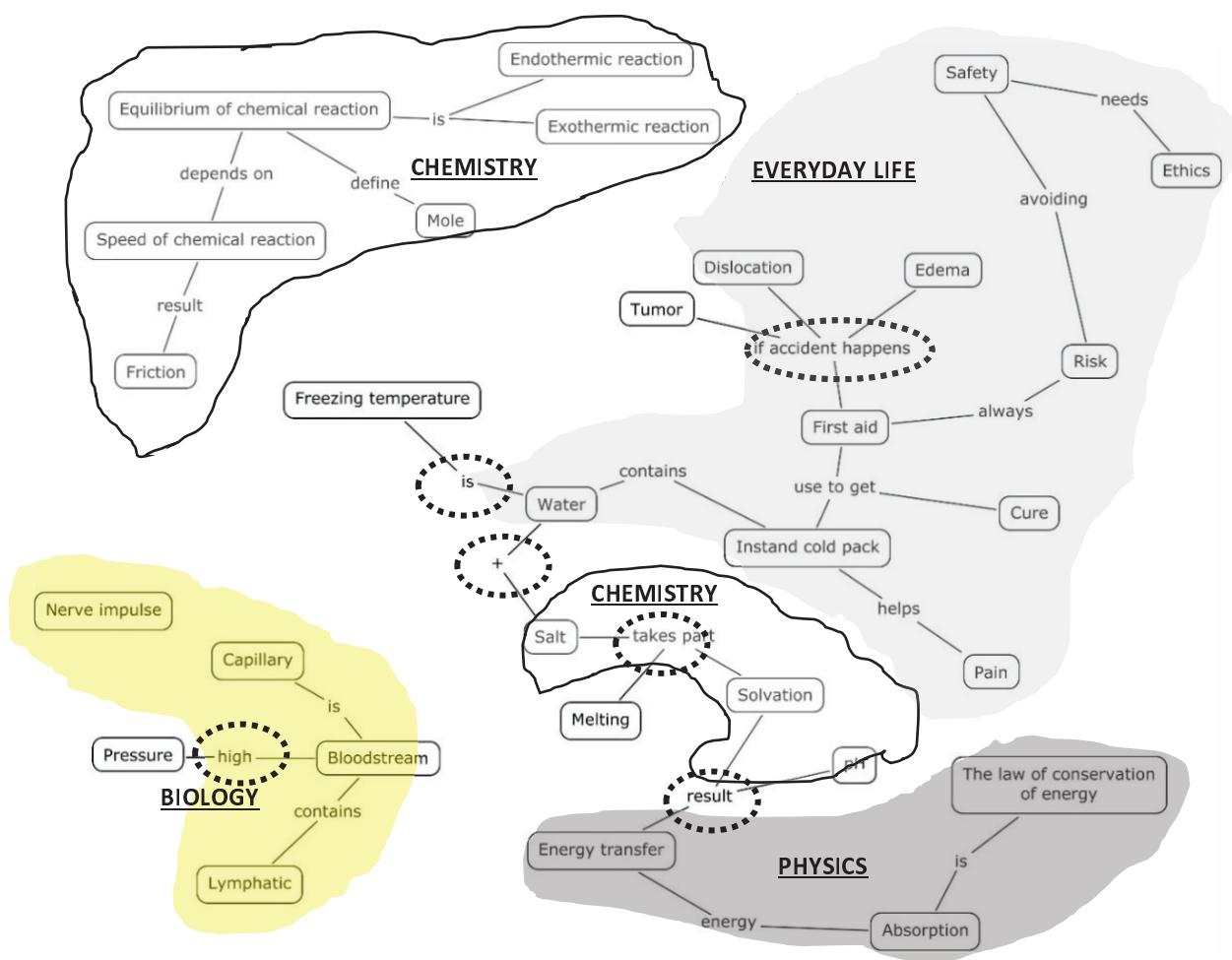


Figure 5. An example of a concept map.

On figure 5, the concept map has 7 interdisciplinary propositions (linking phrases are surrounded with dotted circles) from 26 propositions. The general structure and hierarchy of the concept map are not high. There are discipline based “islands” (surrounded with different coloured shapes). The shape of the concept map is not network, rather consists of several spokes and chains. There are some branch points and one 2-scored proposition. Interdisciplinarity index for that concept map is 0,37.

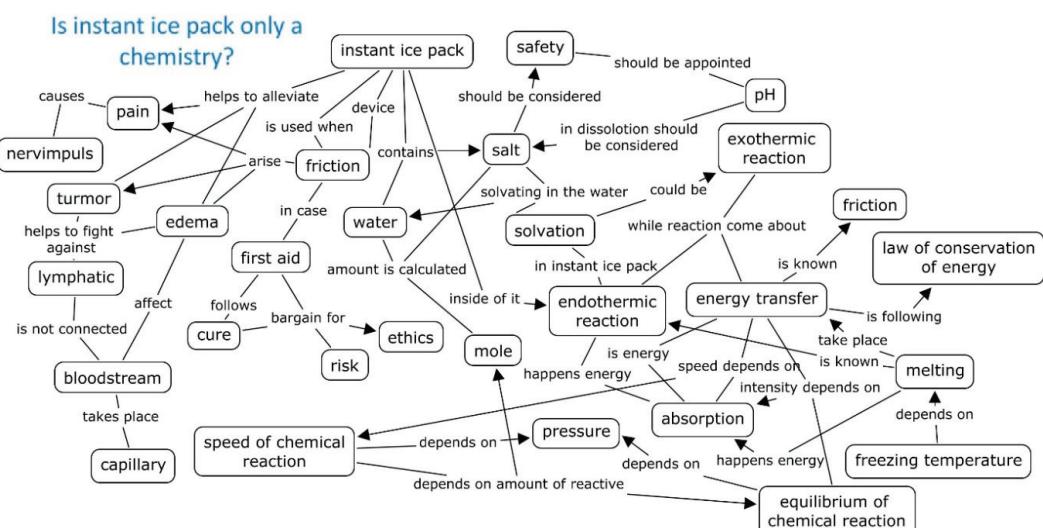


Figure 6. An example of an interdisciplinary concept map.

On figure 6 there is a concept map with 21 interdisciplinary propositions, the structure is “net” shape expressing higher meaningful thinking ability. There are 18 2-scored experts marked propositions and 16 branch points. The interdisciplinary index of the map is 2,1.

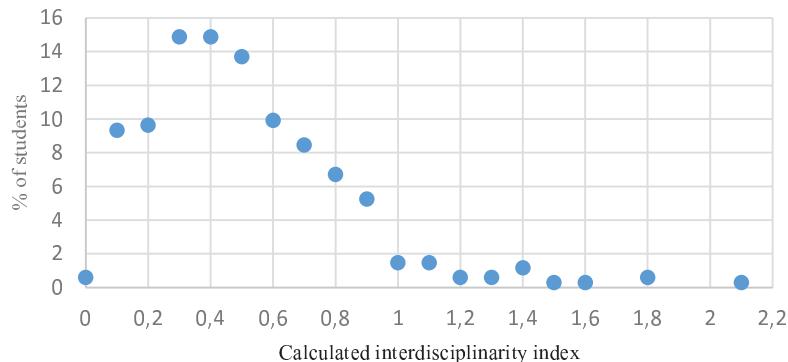


Figure 7. The distribution of calculated interdisciplinarity index.

The results of the interdisciplinarity index varied from 2,1 to 0 as shown in figure 7. Analysis pointed out that only 18,8% of created concept maps achieved 25% of possible interdisciplinary index points. The concept map that has the highest interdisciplinary indexed (2,1) was illustrated in Figure 6. Most of the students (93,6%) got less than 50% of the points of the best concept map found based on interdisciplinary index.

4 Summary

This study pointed out that for assessing students’ interdisciplinary approach, which is one component of scientific literacy skills multidimensional literacy level, we need a flexible and innovative assessment method, for example concept mapping. There are a few studies, where interdisciplinary has been assessed with concept mapping by measuring or calculating certain data. Therefore, this field should be researched more deeply.

The analysis of the concept maps pointed out that high percentage of the students do not create highly valued interdisciplinary concept maps. They prefer connecting one subject based concepts to other one subject based concepts. The reason for that could be the poor use of interdisciplinary teaching approach at Estonian schools. The research also brought out that there are several possibilities for describing concept maps’ interdisciplinary, but not all the options were used here. There are different sides in interdisciplinary concept maps: a) quantity of concept maps’ interdisciplinary: assessed by interdisciplinary propositions count and count of branch points b) the quality of concept maps’ interdisciplinary: assessed by highly subject based scored propositions and also by count of branch point.

5 Acknowledgements

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BECOMING A MENTAL HEALTH NURSE; A THREE YEAR LONGITUDINAL STUDY

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Abstract: This study explores how students' conceptions of 'mental health nursing' changes whilst on a three-year pre-registration Mental Health Nursing programme. The study utilised Novak's approach to concept mapping to elicit student's personal knowledge structures, which were explored further using semi-structured interviews. These were analysed looking at the maps' gross morphology and interpreting changes over time into types of learning achieved. Results suggest that whilst the majority of students learned deeply, some students learned superficially and some appeared not to learn at all. Implications for the professional education of Mental Health Nurses are discussed.

Keywords: Concept mapping, professional education, mental health nursing, longitudinal study

1. Introduction

The process by which people become professionals has been neglected in the educational and professional literature, focussing instead on measuring knowledge and skill acquisition. Nursing in the UK has just become a graduate level profession. This provides a unique opportunity to understand the complexity of *becoming* a mental health nurse in a meaningful and pragmatic way.

The aim of this study was to explore the process of becoming a Mental Health Nurse. The project has run over three years following two groups of students from different universities throughout their degree programme. Students created concept maps to capture their developing understanding of what it means to be a Mental Health Nurse. The project aims to explore the following themes:

- How does the knowledge and understanding of a mental health nursing student change and develop over time?
- How do the course requirements, practice elements and personal experience contribute and shape the experience of becoming a mental health nurse?

2. Methods

2.1 Participants

This study used a convenience sample of students ($n=60$) recruited from the two undergraduate pre-registration programmes in Mental Health Nursing. One university is located in London, UK and the other in the South East of the UK. All students on the first year of the programme were eligible to participate. The data was collected as part of their education programme to encourage critical reflection of what it means to be training as a mental health nurse. Permission to use the data for research purposes was formally requested from potential participants and ethical approval was granted by the Faculty research ethics committee. In the presentation of the results, the student identities are protected by the use of pseudonyms.

2.2 Procedure

The individual concept maps were created using Novak's approach to elicit participants' understanding of 'Mental Health Nursing' (Novak, 1998). Guidance and materials for concept mapping were provided to students during class time in order to make concept maps. Maps were created at the beginning, middle and end of each year of the programme, totalling nine data points across the three years of the nursing programme.

Each map was classified according to the gross morphology of each participant's knowledge structures into spoke, chain or network structures as outlined by Kinchin et al. (2000). The maps were then used to measure

the quality of change in the course of learning into surface-, deep- and non-learning outcomes, as outlined by Hay (2007).

A selection of participants (n=6) were interviewed to explore their maps in greater detail in line with the procedures used in Hay, Wells & Kinchin, (2008) and Bressington, Wells & Graham (2011). The concept maps were used as prompts to facilitate a discussion with the participant (Kinchin, Streatfield, & Hay, 2010) about their understanding of Mental Health Nursing and how their education and practice has impacted on their developing understanding. The interviews were recorded and transcribed. These were analysed using a thematic analysis approach to understand the how participants' understanding of Mental Health Nursing changed during their education.

3. Results

Table 1: Summary of the 6 participants' first and last maps

Participant	First Map			Final Map			Learning outcome
	Structure	Concepts	Links	Structure	Concepts	Links	
Anna	Spoke	8	7	Network	15	25	Deep learning
Ben	Spoke	24	23	Spoke	24	23	Non-learning
Clare	Network	11	12	Network	14	16	Surface learning
Debbie	Chain	19	20	Network	15	23	Deep learning
Ellen	Network	24	28	Network	31	50	Deep learning
Frank	Network	13	13	Network	28	30	Deep Learning

3.1 Anna

Anna's first map is quite simple. It has a spoke structure comprising of 8 concepts with 7 links. This map suggests that Anna has a basic idea of what mental health nursing means at the beginning of the programme and was ready to learn (Kinchin, et al, 2000).

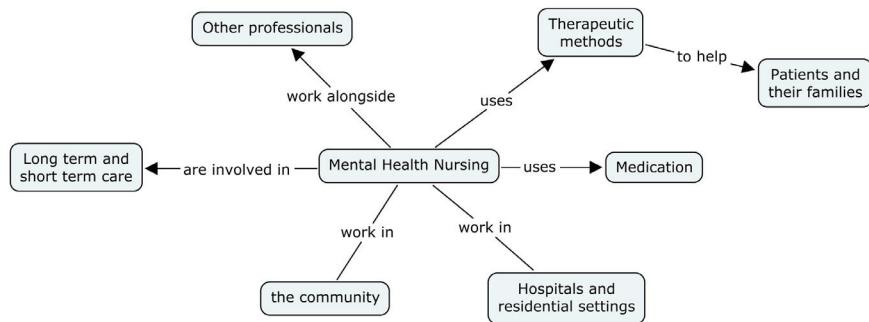


Figure 1: Anna's first map

Anna's final map is structured as a network with 15 concepts and 25 links. This is clearly a more complex structure with greater integration of concepts. Her choice of concepts is more meaningful and shows greater understanding of salient ideas. This suggests she has learned deeply and meaningfully from the programme.

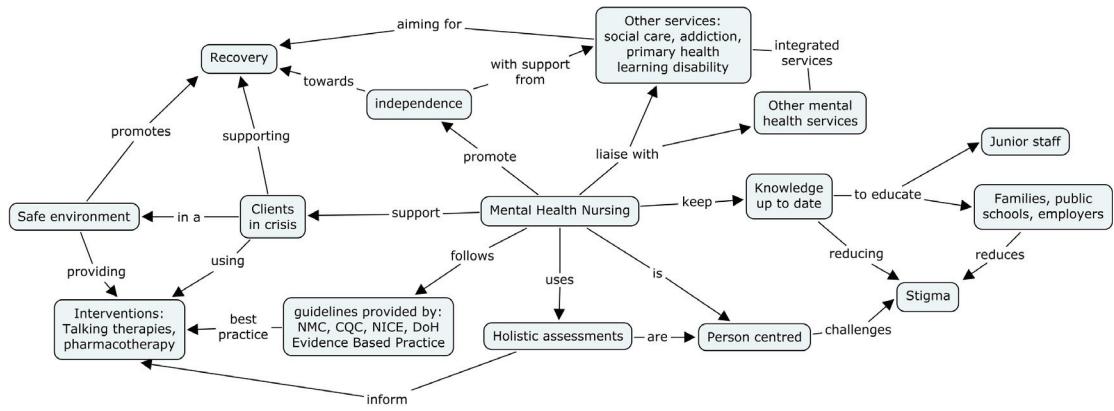


Figure 2: Anna's last map

In interview Anna reported experiencing a significant change in her understanding of mental health nursing as a result of the academic programme and her clinical placements. She reported being able to see her learning in her maps. She reflected upon how naïve her first map was as she has believed Mental Health Nursing was overly simplistic. Whilst her final map is more complex than the first map, Anna reported that she found it difficult to capture the complexity of Mental Health Nursing in a single map.

3.2 Ben

The first map was structured as a spoke with 24 concepts and 23 links. The spoke structure of this map suggests that Ben is ready to learn at the beginning of the course. His use of concepts seems to describe an idealised image of a Mental Health Nurse. This suggests he has an aspiration of what a Mental Health Nurse is and what he hopes to be when he completes the programme.

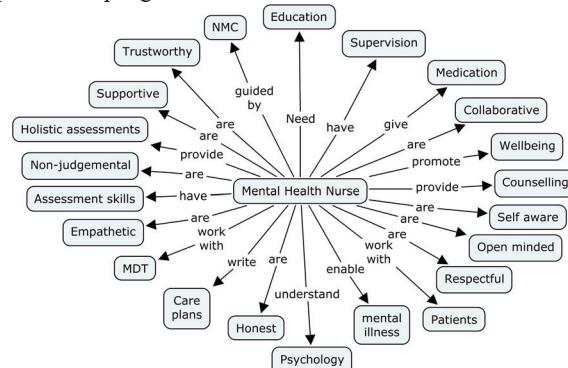


Figure 3: Ben's first map

The final map appeared mostly unchanged with an identical number of concepts and links to the first map. Whilst some of the concepts had changed none were well integrated into the structure. This suggests that Ben has not achieved the change he aspired to at the beginning of the course. This lack of change in knowledge structure suggests that Ben had not learned from the course.

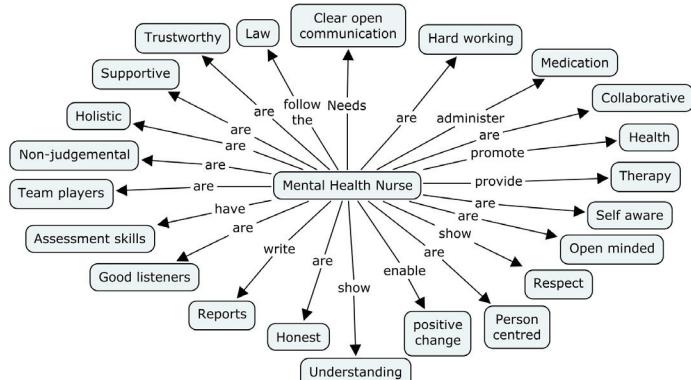


Figure 4: Ben's last map

In interview, Ben reported that he learned most from clinical practice and often found it difficult to relate academic concepts to clinical practice in a meaningful way. For Ben there was a clear theory-practice gap, which he has been so far unable to bridge. He appears to have adopted a strategic approach to learning; he has met all the requirements of the course but his knowledge structure remains largely unchanged.

3.3 Clare

Clare's first map is a simple network comprising of 11 concepts and 12 links. These are loosely integrated with minimal linkage between many of the concepts. Some of the concepts are about Clare's choice for starting a course in Mental Health Nursing; she identifies that 'Mental Health Nursing is rewarding' and 'provides an opportunity to move up in [her] career'. This suggests the course is a strategic move with other areas of Mental Health Nursing showing only a superficial understanding; e.g. 'Vulnerable people needing treatments'.

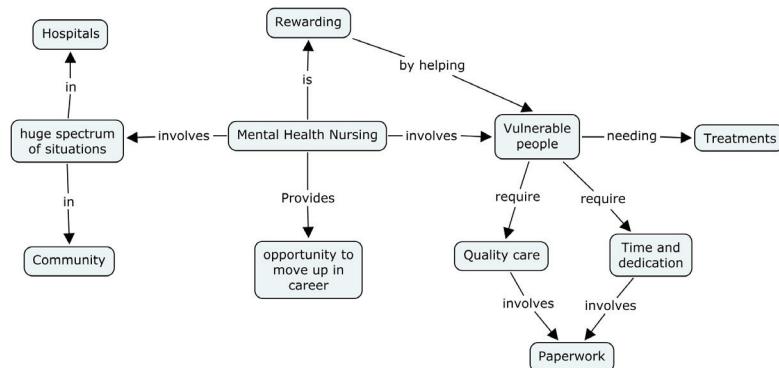


Figure 5: Clare's first map

Clare's final map is also a network and is comprised of 14 concepts and 16 links. There has been an increase in both concepts and links, and the concepts are more meaningful. However, these concepts are not well integrated into the map. For example, 'Person centred' is a concept that underpins nursing care and is yet only superficially integrated in this map. 'Recovery' is a key idea in contemporary Mental Health Nursing, like 'Person centred' care, is a driver to all other aspects of care delivery. All paths in Clare's map lead to 'Recovery', suggesting that for Clare Recovery is an end product of the work of a Mental Health Nurse, rather than it being a fundamental guiding principle. All of this suggests Clare has learned strategically and superficially.

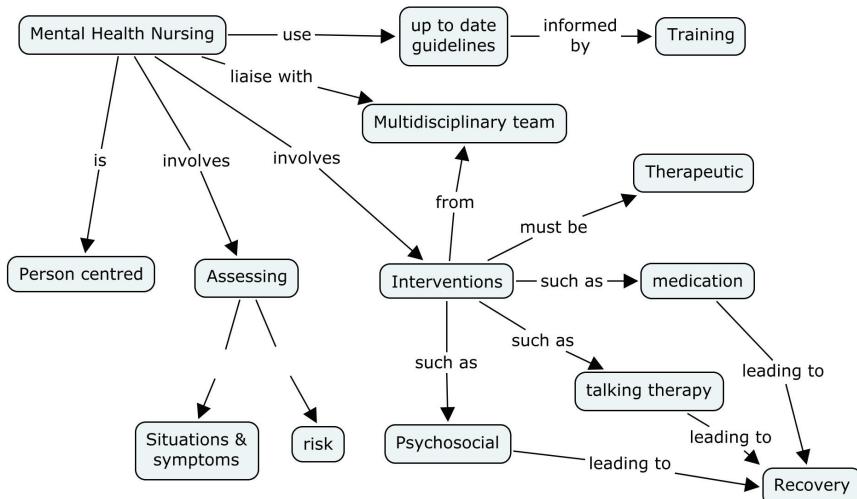


Figure 6: Clare's last map

Clare reported in interview many of the concepts in her maps unproblematically. She was able to reflect that her initial understanding of Mental Health Nursing was superficial but did not see the same qualities in her final map.

4. Discussion

It is clear from a brief glance at the maps that they have not been structured hierarchically. Whilst this is a deviation from the guidelines for concept mapping it is entirely understandable given the abstract nature of Mental Health Nursing. Trying to decide which is a higher level concept, empathy or medication is a problem that has been encountered previously in exploring Mental Healthcare using concept mapping (for example see Bressington, Wells & Graham, 2011, or Bressington, Mui, & Wells, 2014).

The presence of superficial and non-learners on a three-year nursing programme is somewhat surprising and disappointing. Nursing students in the UK have to complete 2300 hours of theory and 2300 hours of clinical practice to be eligible to be included on the nursing register. It is astounding to believe that someone can spend that much time in a classroom and in clinical settings and not be changed by the experience. Perhaps the drive towards competency has influenced what people focus their attention towards.

The Chief Nursing Officer required all nursing programmes to assess specific competency themes throughout the training (CNO, 2010). However, educational researchers argue that competency benchmarks fail to capture the essence of what it means to be a professional as they highlight the technical aspects rather than the values that underpin the profession. Eraut (2009) argued that professional competencies create ‘the widespread delusion that a professional qualification represents competence in some all-encompassing generic form’ (p.6). The finding that students can emerge from a three-year programme with their original knowledge structure unchanged challenges the notion that competencies are worth assessing.

Another possibility is that the nature of the research study has influenced some of the participants to take a strategic approach to developing their concept maps. Given that maps were created three times during each academic year for three years makes this a repetitive task with no university credit assigned to the task. The interviews were used to explore the individual’s perception of the topic and no feedback was provided to the participant about the quality of the map. This may result in the participant feeling frustrated and, not wanting to ruin the research or upset the researchers, took a strategic approach and did not put much effort into their map. Whilst this is possible, it is inconsistent with the researchers’ experience of working with the participants. The participants attended the research sessions regularly and were active contributors during interviews. This suggests that the concept maps are reliable and valid measures.

Several students highlighted a theory-practice gap in their education. They reported learning one thing in university and seeing another in practice. This discrepancy between what one is taught and what one actually does created a problem for a number of participants resulting in confusion and frustration. This is clearly an ongoing issue for nursing education. As the division between universities and clinical areas appears to grow proactive strategies are needed to address this.

The majority of students did achieve deep meaningful learning whilst on the nursing programme. Many of these students reported experiencing a personal transformation whilst on their training (Mezirow, 1990) and this appeared in several students’ maps as described by Hay, Wells, & Kinchin, (2008). Transformation was a more common outcome of the programme than non-learning. This is a positive outcome of the programme and a more detailed examination of the data will reveal more about the transformational nature of professional education.

5. Limitations

One limitation of this study is that the participants who took part in the interview aspects of this study were largely self-selecting. Whilst it does not undermine their own concept maps or learning trajectory, it may exclude the less enthusiastic or less outgoing students from participating in this part of the study.

A further limitation of this study is that the researchers are tutors on the nursing programmes and this may have influenced both the students’ responses and the interpretation of the findings. An attempt to manage this was achieved by each researcher leading the study in the other’s university and interviews were conducted by the external researcher.

6. Conclusion

This study has reported on the early findings of a three year longitudinal study exploring how students' perceptions of Mental Health Nursing changed as a result of their educational programme and clinical practice. The study has revealed that most participants have learned deeply and experienced transformative learning experiences whilst on their professional training. However, some students appear to have learned strategically and others appear not to have learned from the programme. This has raised issues of competency-based trainings and the widening theory-practice gap in professional education. A more detailed analysis of this longitudinal data will no doubt reveal further insights into professional training programmes.

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CMAP READABILITY: PROPOSITIONAL PARSIMONY, MAP LAYOUT AND SEMANTIC CLARITY AND FLOW

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Abstract. In our experience of introducing concept maps (Cmaps) to practitioners, we have seen a vastly positive reception of the tool's capability as an analytic support, however only a lukewarm response to using Cmaps for communicating information to decision makers. In this paper we focus on the map reader and human factors of Cmap readability. We look into what makes a Cmap reader-friendly in terms of its scope and organization, and examine three aspects of map readability – propositional complexity, map layout, and semantic flow and clarity. We draw on some basic principles of human information processing, such as working memory capacity and Gestalt principles of perceptual organization to better understand how maps can be designed to help readers extract information from them with less effort. The application of these principles encourages greater use of the (largely underutilized) "visual" aspect of Cmaps through modification of their layout, which in turn can facilitate semantic clarity and flow of the map content. The application of perceptual organization principles to Cmap design can facilitate chunking of map elements and, thereby can help reducing cognitive load and simplifying processing of the presented information.

Keywords: Concept Mapping, Cmap analysis, Cognitive load

1 Introduction

Since its development in the 70s, Concept mapping (Cmapping) has seen growth both in its theoretical development (e.g., Cañas & Novak, 2006; Miller & Cañas, 2008; Novak, 1994; Safayeni et al, 2005) and its practical application (e.g., Cañas et al., 2012; Daley et al., 2008; Moon et al. 2011; Nesbit & Adesope, 2006). For a number of years now, we have been introducing Cmapping to Canadian civilian and military public service professionals emphasizing their analytic and communication functions. In our experience, we have encountered mostly positive reaction towards using Cmaps for their analytic support capability, i.e., as a way to structure, externalize and advance their own understanding of a topic or a problem through building a map. However, we have seen a variety of reactions from decision makers when they were presented with critical information in a Cmap format. In these situations, the primary purpose of the Cmaps was to provide a decision maker with the necessary information to improve their situational awareness and to enable them to make better decisions. The decision makers did not participate in the creation of the maps, they were only map readers, and their reactions to this communication format ranged from the immediate embrace to the rejection of the idea.

There could be many reasons for some practitioners' lukewarm reception or even rejection of Cmaps as a communication medium. Some of these reasons could be due to individual preferences/differences of the map readers, other reasons could be due to compatibility/congruity between the medium and the content. For example, expressing ideas in a Cmap form that could be better expressed in another format. On the other hand, the Cmap might be an optimal medium, but inadequate human factors design of the product can compromise its usefulness. The human factors of map design plays an important role in how map readers perceive Cmaps and, subsequently how effectively maps can communicate information to their readers.

In this paper we focus on the map reader and human factors of Cmap readability. We consider what makes a Cmap reader-friendly in terms of its scope and organization and examine the possibility of facilitating readers' acceptance of Cmaps as a communication tool through improving their design and layout. We draw on some basic principles of human perception and information processing (e.g., Miller, 1956; Wertheimer, 1958) to better understand how maps can be designed to help readers extract information from them with less effort. This paper mainly presents theoretical arguments and it does not provide any empirical evidence for the arguments made. Empirical tests of the presented ideas are subject of future research.

2 Aspects of Cmap readability

Reader's acceptance of a CMap as a source of information and the amount of effort that he or she will be willing to invest into traversing the map depends to a great extent on how easy it is to extract information from the map, i.e., its readability. Different aspects of the map content and design contribute to its readability. For the purpose

of our subsequent discussion we would like to emphasize three map properties that in our view are closely related to map readability: Propositional complexity, semantic flow and clarity, and map layout.

- *Propositional complexity* refers to the number of concepts and relationships in the map.
- *Semantic flow and clarity* refers to the expression of concept labels and linking phrases and the map reading flow.
- *Layout* refers to the spatial organization of the map elements and their visual properties.

These three properties are not independent of each other. For example, map's propositional complexity constrains semantic flow and the range of possible layouts. However, each of them highlights a different aspect of the overall map and contributes to its readability in a different way. Therefore, it is worth examining them individually.

Propositional complexity determines the overall scope of the map, and thus the amount of effort that will be required on the part of the reader to traverse and understand it. The more complex a map is the more effort a map reader will need to invest into traversing it. In a map designed for communication, a fine balance between inclusiveness of the content and parsimony needs to be maintained. It is possible to connect every imaginable pair of concepts in a map with a linking phrase, however not all of these connections are required to answer the map's focus question. Often, secondary relationships included in the map unnecessarily increase its propositional complexity and obstruct (as opposed to facilitate) comprehension. Ideally, a map will contain all the necessary information to answer its focus question, but not more than that. In other words, propositional parsimony in the map design is highly desirable.

Semantic clarity and flow focus on the articulation of map elements and reading simplicity. Labelling precision of the map elements, brevity, ensuring and maintaining a natural reading flow can significantly improve map readability. Semantic clarity and flow depends on the choice of words and grammatical structures of propositions and their consistency with the visual information conveyed through the map structure and directionality of the relationships. For example, a proposition phrased in active voice is easier to comprehend than a proposition phrased in passive voice (e.g., APA, 2001; Silvia, 2007). In addition, a proposition stated in passive voice goes against the visual flow of the arrow line on which it is stated, thus creating an incongruity between the visual and semantic information in the graph, thus disrupting the flow.

Map layout property focuses on the arrangement of map elements in the available space with the aim of visually emphasizing map's content without altering its semantics. Traversing a Cmap is predominantly a reading task with most of the information being communicated through the labels of the map elements. Map structure transmits some information (e.g., Carvajal & Cañas, 2006); however the visual capabilities of a map as a *graphic representation tool* are often underutilized to a large extent. We believe that making greater use of map's graphic nature can facilitate its readability and reader's acceptance.

The scope of this paper does not permit an in-depth discussion of all aspects of each of these properties, and we did not attempt to provide a comprehensive coverage. Instead, in the remainder of this paper we discuss how some basic principles of human information processing, such as working memory capacity and principles of perceptual organization, can be applied to the above properties to facilitate map readability.

3 Propositional parsimony and working memory capacity

Propositional complexity in Cmapping as we define it refers to the number of concepts and relationships represented in a map. While a map needs to include all the relevant information to provide an answer to its focus question, there is always a tradeoff between inclusiveness and readability. When the primary purpose of the map is self-inquiry, i.e. the map is intended for clarifying one's own thoughts, but not for communicating to someone else, then map's readability is not a major concern. However, when the primary purpose of the map is communication, this tradeoff becomes especially salient, because after a certain threshold there is an inverse relationship between the map size – its propositional complexity – and its readability.

Cmap readability is closely related to people's ability to process information. The amount of information that people can manipulate in their working memory (WM) is limited (Miller, 1956). The WM capacity limitation has implications for Cmap design especially when a map is intended to communicate information. Ideally, a well-designed map should not overwhelm its reader's WM. A commonly cited rule of thumb for WM capacity is the famous 7 ± 2 (Miller, 1956). This rule of thumb implies that the amount of information that a person can manipulate at a time roughly varies between about five and nine "chunks" of information. The notion

of “chunk” is critical here, because the way the information is organized (or chunked) determines how much of it we can process.

To cope with the multitude of information in the environment, our mind organizes the information it perceives, it groups elements that go together into units for more efficient processing (Wertheimer, 1958). For example, consider the following string of letters “L-F-O-W-T-M-O-T-B-L-E-H-O-H-L-E-R-L-S”. The string contains 19 letters, and an average person will have difficulty remembering and reproducing this string one letter at a time, because the size of the string exceeds our WM capacity. However, if we unscramble the string and group the letters into the following words – chunks – “FOR WHOM THE BELL TOLLS”, the same 19 letters become much more manageable and easier to remember. If we go a step further and present a set of five other Hemingway’s titles, then a person familiar with his writing will see each title as a single chunk, and remembering six familiar titles will not be a problem. As a result, the array of letters that a person can manipulate when they are grouped in such manner is much larger than a set of individual letters.

Same applies to reading a Cmap – map reader’s capacity to process map’s content depends on how he or she chunks information in the map. A Cmap consists of elements - concepts and linking phrases – that could be naturally grouped into propositions – concept-link-concept triads. If no further higher-order grouping is done beyond propositions, then a map with nine propositions already approaches the WM capacity limit. Nine propositions is not that many – a fairly small Cmap with six reasonably connected concepts can easily contain nine propositions. In this light, propositional parsimony achieved through careful discrimination in selecting propositions to be included in the map designed for communication becomes extremely important.

Is it possible to convey all the necessary information to the reader with six concepts and nine or so propositions? In some cases perhaps yes, but most likely nine propositions will not be sufficient. How then can we design maps to convey all the necessary information without overloading the reader? One solution could be to create multiple small maps or knowledge models. Creation of knowledge models is a very interesting topic that requires a discussion of its own; however it is beyond the scope of this paper. Instead we will focus our attention on examining how we can relax propositional parsimony through facilitating higher-order chunking of the map elements to allow for a more efficient processing of the map’s content.

Higher-order chunking goes beyond individual propositions and refers to grouping of two or more propositions together, which are then processed as a single unit. This is similar to the grouping of words into a novel’s title in the letter-string example above. A reader is able to process more propositions when they are grouped into bigger chunks than when these propositions are processed individually before reaching his or her WM capacity limitation. Grouping reduces the amount of effort a reader needs to put into processing the content. In other words, higher-order grouping might allow the map builder to relax some propositional parsimony, and include more propositions without overloading the reader. Map readability depends on the interplay between propositional complexity and the way the reader intuitively groups them.

The letter-string example above suggests that chunking information draws on the person’s prior knowledge and the ability to see patterns. For example, someone who does not speak English will not be able to group the letters in the letter-string example into English words, but he or she might be able to group the letters in some other way. Therefore, understanding the map audience’s prior knowledge is critical for not only excluding familiar and redundant information from the map, but also for anticipating how the reader will be able to chunk the information presented in the map.

The way the reader perceives and groups propositions in a map greatly depends on his or her background, and it could be outside of the map creator’s control. However, the map creator can employ certain mechanisms in the design and layout of the map that can facilitate or discourage certain grouping. The way the information is presented and visually organized significantly influences its readability and the amount of effort required by the reader. For example, in writing we put letters that form a word close together and separate each word from other letters and words with a space on each side. This creates a visual chunk that we recognize as a word. Visual presentation of information could be a powerful chunking mechanism, which is especially relevant to Cmapping, because Cmaps rely on spatial layout. In the following section we examine what contributes to grouping of map elements and how to facilitate semantic flow and higher-order chunking in Cmaps through their layout.

4 Map layout and semantic flow

Cmaps are *visual* graphs. However, most of the maps that we have seen rely on their semantic content (i.e., concept and linking labels) for communication and largely underutilize the communication capabilities of graph's visual properties. We argue that map layout and its visual features can be used to augment map's semantic content with information that can help establishing further relationships among concepts. To achieve this, Cmap design and layout can leverage basic principles of human perception, to make greater use of the "visual" aspect of Cmaps. Enhanced visual layout of a map can encourage higher-order chunking of map elements, help establishing a smoother semantic flow in the map and facilitate readability and comprehension of its content (Miller, 1956; Wallace et al. 1998).

Gestalt psychologists laid out several principles of human perceptual organization that describe general tendencies of how the visual system organizes or makes sense of the world (e.g., Wertheimer, 1958). The main idea behind these principles is that, whenever possible, we see patterns and larger units, as opposed to a disorganized array of information. This tendency to organize our visual field allows us to cope with the vast multitude of information in our environment. First, we briefly review seven Gestalt principles of perceptual organization, and after that we discuss how each of them can be used to facilitate Cmap layout and reading flow.

- *Law of proximity* states that elements close to each other tend to be perceived as a group. For example, in Figure 1 a) people tend to see two columns of stars that are closer together as a group. Another example is separation of letters that form a word from other letters with a space on each side, thus using proximity to encourage grouping of the letters into a word.
- *Law of similarity* states that elements that are similar to each other tend to be perceived as a group. In Figure 1 b) people tend to see columns of stars and circles, as opposed to rows of alternating stars and circles.
- *Law of continuity* states that objects that are aligned with each other tend to be grouped into wholes. In Figure 1 c) people tend to see two intersecting lines consisting of triangles.
- *Law of common fate* – states that elements moving in the same direction tend to be grouped together. Demonstration of this law requires a dynamic image and no illustration is included.
- *Law of Pagnanz* – or the law of good figure (good Gestalt) – states that ambiguity in the input is reduced in favor of the simplest form possible, in other words, elements tend to be grouped together if they are parts of a simple, orderly, coherent pattern, which is a good Gestalt. In Figure 1 d) people tend to see five rectangles – the simplest shape to which the image can be reduced.
- *Law of closure* – we tend to ignore gaps and fill in the missing information. Although, the triangle in Figure 1 e) is not complete on one side, people still tend to see that shape as a triangle, by filling in the missing information.
- *Figure-ground articulation* states that images are perceived as articulation of the figure on the ground. While the figure is the focus of attention, background defines how the figure is perceived. Figure 1 f) is a classic example of the figure-ground paradox – vase and two faces. Depending on which aspect of the image the viewer is focusing he or she will either see the white vase or two black profiles. In either case the background of the image defines the figure.

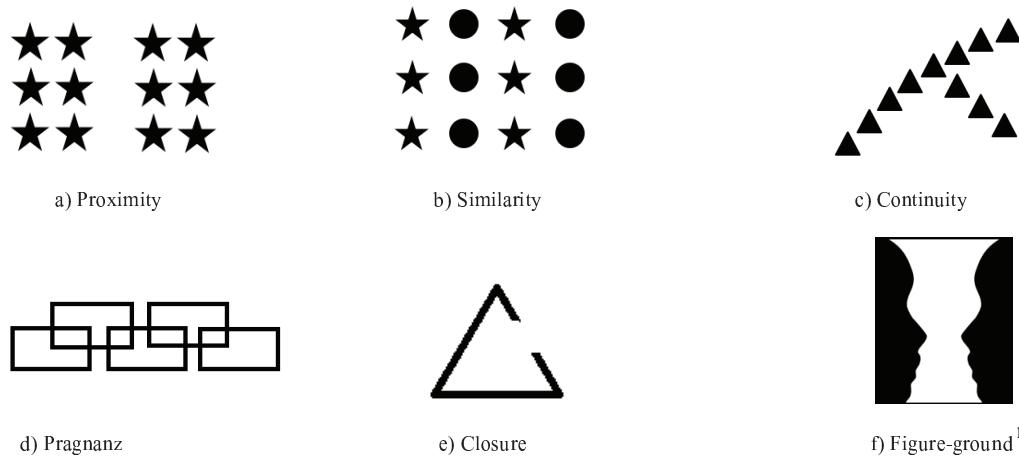


Figure 1: Illustrations of Gestalt principles of perceptual organization

¹ The image is by Bryan Derksen [GFDL (<http://www.gnu.org/copyleft/fdl.html>) or CC-BY-SA-3.0 (<http://creativecommons.org/licenses/by-sa/3.0/>)], via Wikimedia Commons

We see natural connections between some of these principles, and Cmap design. Below we explore how some these principles in relation to Cmap design and examine how they can be leveraged through Cmap layout to facilitate grouping and semantic flow.

The *law of proximity* is the most natural principle in the Cmapping context. This law implies that map elements that are put closer together are more likely to be grouped together. Therefore, map's spatial layout, specifically, reducing or increasing the distance between the elements, can be used to encourage grouping of some concepts and propositions and to differentiate them from other elements. Spatial layout can be used to articulate branches (or domains) in a map. For example, in Figure 2 concepts *B*, *C*, *D* and *E* are likely to be perceived as a group because of their proximity to each other, as well as concepts *G*, *I* and *J* are likely to be grouped together. The proximity principle also suggests that if the two concepts from the same proposition are spaced far apart, it will be more difficult for the reader to see them as a unit. For example, in Figure 2 concepts *A* and *J*belong to the same proposition, but they are less likely to be grouped together because of their distance.

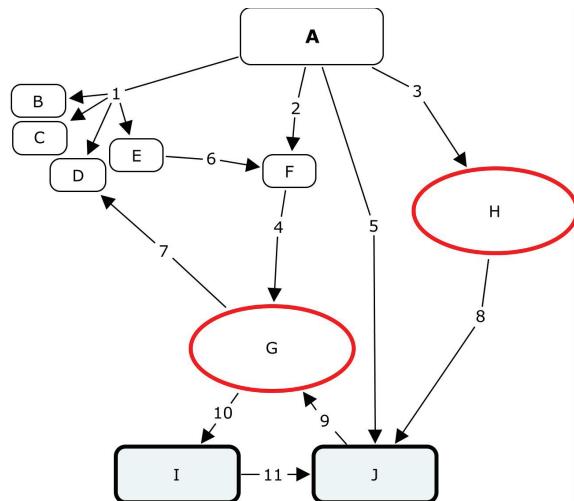


Figure 2: Example of applying some of the Gestalt principles to Cmap design.

The *law of similarity* implies that Cmap elements that share visual features will be grouped together. Similarity of elements in CMaps can be reinforced through the use of color, size, shape type, border style, font style – the use of all capital letters in concept or link labels. Although in their preliminary investigation, Carvajal and Cañas (2006) did not find an impact of color on the perception of Cmap quality, we believe that color can be effectively used to reinforce the Gestalt law of similarity in a CMap and to facilitate Cmap readability. For example, a certain color could be used to differentiate types of concepts, e.g., using red color to highlight the most dangerous elements in a situation. For example, in Figure 2 concepts *G* and *H* are likely to be perceived as a group because of the similarity of their features, similarly, concepts *I* and *J* are likely to form a group too.

The *law of continuity* in the Cmapping context can be translated into the flow of the map's content and the agreement between the visual structure and semantics. Propositions that follow smooth reading flow will be more likely grouped together. Smooth reading flow in a map can be achieved by reducing some of the flow disturbances due to the choice of semantics and their relationship to the map structure, arrow directions and structural dead ends. Below we discuss three considerations in map reading flow: a) the use of active and passive voice in linking phrases; b) adhering to the natural reading flow direction; c) reducing the number of sink concepts².

- Active and passive voice. Cmaps have unrestricted semantics, which makes them a very flexible representation tool. Unrestricted semantics means that linking phrases can be stated both in active and passive voice, for example, see Figure 3. Passive voice can emphasize certain elements of a sentence, however in the Cmapping context, a linking phrase in passive voice contradicts the flow of the relationship and the direction of the arrow on which it is stated. That is, the starting concept in a passive voice proposition is actually the end concept of the relationship. In the “John loves Mary” example of Figure 3, the direction of the relationship between John and Mary starts from John and ends with Mary as shown in Figure 2 a), i.e., John is the actor. However, if we use passive voice in the linking phrase,

² The term “sink” concept is borrowed from graph theory that defines sink vertex as a vertex with outdegree of zero, i.e., with no outgoing connections.

as in Figure 3 b), then we have to reverse the direction of the arrow, which visually contradicts the actual nature of their relationship and implies that Mary is the actor. Thus, the use of passive voice in linking phrases creates a flow disturbance between the semantic content and its visual presentation.

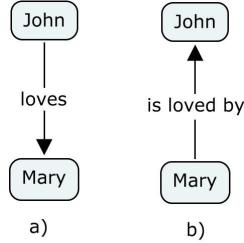


Figure 3: Example of a proposition stated in active (a) and passive (b) voice.

- Natural reading flow. The natural reading convention of most western languages is from top to bottom and left to right. A more natural reading flow will presumably require less effort on the reader's part. CMap's hierarchical organization naturally encourages the flow of relationships from top to bottom. The more a map adheres to these flow conventions the easier (i.e., requiring less cognitive work) it should be for the reader to traverse the map. For example, in Figure 2, reading proposition $A \rightarrow 3 \rightarrow H$ is probably slightly more natural than reading proposition $G \rightarrow 7 \rightarrow D$.
- Continuous flow. Continuous flow in a Cmap refers to its reading flow that progresses from concept to concept through their linking phrase and continues to the next proposition without interruption. For example, in Figure 2 the sequence of concepts $A \rightarrow E \rightarrow F \rightarrow G \rightarrow I$ forms a single continuous sequence. The flow is maintained through concepts' outgoing relationships and it is disrupted by the presence of sink concepts – concepts that do not have any outgoing relationships, but only incoming, e.g., concepts B , C , and D in Figure 2. Upon reaching a sink concept the reader has no choice but to stop traversing the map and start again from somewhere else in the map. Naturally, this breaks the reading flow. Such reading interruptions are unavoidable in Cmaps, but there are ways to reduce their number, for example by adding a connection. An effort to reduce the number of sink concepts can also encourage connecting concepts in other areas of the map, potentially creating cross-links and loops, both of which are considered to be desirable properties in maps (e.g., Miller, 2008).

The *law of common fate* can be operationalized in the Cmapping context through the use of branching linking phrases (Miller, 2008). A branching linking phrase connects one concept to several other concepts, e.g., in Figure 2 linking phrase I is a branching linking phrase that connects concept A with B , C , D , and E , therefore one linking phrase represents four propositions: $A-B$, $A-C$, $A-D$ and $A-E$. Such linking phrases act as natural grouping nodes for the group of concepts (in our example, boxes B , C , D , and E) on the basis of their identical relationship to the single concept (in our example, concept A). This grouping can also be reinforced with the relative proximity of the concepts in the group as in Figure 2.

Figure-ground articulation. Many maps that we have seen lack articulation – all boxes and arrows have the same format and are more or less uniformly spread out (or bunched up) on the available real estate of the map. The entire map looks like a uniform network of boxes and arrows with no focal points. In such situation the reader (especially a novice Cmapper) cannot discern much information about the map by simply glancing at it. For instance, it is not obvious to the reader which concepts are more important, what domains the map consists of, and how to traverse it. Visual features (such as size, color, font, line thickness, etc.) could help to differentiate some elements in a map from the rest, making them more salient and directing the reader's attention. For example, in Figure 2 concepts G and H attract attention due to their unique shape and red outline. Also, several regions in the Figure 2 map emerge visually: $B-C-D-E$ group; $G-I-J$ group, $G-H$ group, as well as standalone concepts A and F .

The direct application of the *law of pragnanz* and *closure* to the Cmapping context is not as apparent. The law of *pragnanz* emphasizes the organization of the visual field into simple coherent forms. However, it is not entirely clear what this entails for Cmap design. Perhaps, it could imply that a map needs to have easily recognizable regions and have a structure consistent with its content. The law of *closure* states that people tend to fill in the missing information to complete a good Gestalt. Again, it is not clear how the *law of closure* can be easily applied here. These two laws may not be relevant in the Cmapping context.

The example in Figure 2 demonstrates several of the above ideas. This map does not contain any real concept and linking labels to demonstrate how visual properties of map elements and map layout can encourage

grouping in a map and articulate some of its components. For examples, the laws of *proximity*, *similarity* and *common fate* reinforce the grouping of concepts *B*, *C*, *D* and *E*; the law of *similarity* encourages grouping concepts *G* and *H* and concepts *I* and *J*; concepts *I*, *J* and *G* can also form a group reinforced with the law of *proximity*. A few distinct segments emerge in the map and they can guide reader's traversing of the map. Although, the map contains ten concepts and 14 propositions, it seems to be quite manageable because of the grouping of the map elements.

In terms of the reading flow, the map in Figure 2 has several continuous reading paths: e.g., using the numbers used on the linking phrases, one possible path is 1-6-4-10-11-9-7, another one is 3-8-9-10-11-9-7, yet another one is 2-4-10-11-9-7. A couple of relationships – 7 and 9 – go against the top-bottom convention, however in one case – 7 – the relationship connects visually different segments of the map; and in the other case – 9 – it facilitates the continuity of the flow. The map contains several sink concepts – *B*, *C*, and *D*, however these concepts are part of a *B-C-D-E* chunk, which has an outgoing relationship through concept *E*.

The suggested visual map modifications are fairly easy to implement with the available software, such as CmapTools (Canas et al., 2004). CmapTools provides a rich repertoire for enhancing visual features of boxes, lines and text in maps including manipulation of their font, type, color, style, shape and fill. Other aspects of map reading flow, such as active voice linking phrases and directionality and connectivity of concepts require examination of map content and making necessary structural and semantic adjustments.

5 Conclusion

As a knowledge representation tool, Cmaps have much to offer – they are a flexible tool that helps to externalize and articulate knowledge in a concise manner. The analytical power of Cmapping is fairly easy to see with even a brief introduction to the method. Cmaps can also be a powerful communication tool; however, their communication capability can be obscured with propositional excessiveness, poor layout, obstructed flow and a lack of articulation. We argue that in order to take advantage of Cmaps's communication capability the map creator needs to pay special attention to map readability. CMap readability mainly concerns with the ease with which a map reader can extract information from the map.

Map readability is a multi-faceted concept, and this paper examined three (of the potentially many) of its aspects – propositional parsimony, map layout and semantic flow and clarity. We argue that human working memory capacity limitation is a major factor in determining the amount of effort the reader will need to invest into traversing the map. Propositional parsimony in a map is required in order to not to overwhelm readers' working memory. However, the WM capacity limit can be stretched by encouraging higher-order chunking of map elements. Manipulating the design and layout of the map while relying on some of the Gestalt principles of perceptual organization can facilitate more advanced grouping of map elements. Such Gestalt principles as figure-ground articulation, the law of proximity, similarity and common fate are particularly applicable in the Cmapping context. In other words, an effective map layout can allow including greater number of propositions in a map without overloading the reader, which allows relaxing, to some extent, the requirement of propositional parsimony.

Another aspect of Cmap readability is semantic flow and clarity. We argue that smooth reading flow can reduce the amount of effort on the part of the reader. Relying on active voice in labelling linking phrases, reducing the number of sink concepts, and adhering to the natural reading direction can help achieving smooth reading flow in a map. While it is quite possible to completely avoid the use of passive voice in a map, it is not possible to completely eliminate sink concepts and design all propositions in the direction from top to bottom and left to right. However, a map designer aware of these issues can try to minimize disturbances in the map reading flow. Semantic clarity in a Cmap goes beyond map's reading flow. It also concerns the construction and articulation of concept labels and linking phrases. We briefly touched on one aspect of linking phrase articulation; however, we did not discuss the construction and articulation of concepts. This is an important topic that requires extensive examination, but it is outside the scope of this paper.

This paper presents theoretical arguments. We have not empirically tested these ideas; however, this could be done. For example, a test can be devised in which participants have to study the same Cmap in either a plain layout or in enhanced layout. A number of measures can be collected, such as time to traverse the map, content retention, perceived cognitive effort, subjective evaluation of the map, etc. Such empirical investigations are subject of future research.

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CMAP TOOLS COMO ARTEFACTO DE MEDIACIÓN DIGITAL PARA PROMOVER LA CONSTRUCCIÓN DEL CONOCIMIENTO Y EL APRENDIZAJE EXPANSIVO

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Resumen: Se hizo una investigación comparando dos cursos universitarios que utilizaron Cmaps. La variante consistió en la intensidad de exposición (baja y alta) de los mapas conceptuales elaborados por los estudiantes. Se encontraron diferencias estadísticamente significativas entre la ejecución del grupo de baja intensidad y el de alta, obteniendo indicadores favorables que denotan mayor complejidad en los mapas del grupo de alta intensidad, tal y como se planteó en la hipótesis de trabajo.

Palabras clave: Cmaps, Aprendizaje expansivo, Mediación digital, Construcción conocimiento.

1 Introduction

Uno de los problemas más complejos en la enseñanza es promover la lectura activa, la cual se puede lograr cuando al lector se le requiere que construya un mapa conceptual de lo expresado en el texto. En contraste, en la lectura pasiva donde no hay requerimiento constructivo, la capacidad de reflexión, comprensión y comunicación se limita, en tanto el alumno no tiene elementos para deliberar con sus compañeros a profundidad y construir conocimiento en una ruta de aprendizaje expansivo (ampliando el espectro temático).

Consideramos que una buena alternativa a la lectura pasiva, es promover la lectura activa a partir de la exigencia a cada alumno de entregar un *mapa conceptual* por cada lectura curricular requerida en un curso. Esto hace que cada alumno tenga que *construir* una expresión de su pensamiento a partir de una representación de su lectura, estructurada en un mapa cognitivo, lo que es acorde con las teorías del *constructivismo*.

Los *mapas conceptuales* constituyen un artefacto, de acuerdo con la *teoría de la actividad*, muy apropiado para promover la lectura activa, en tanto exige desde su inicio la reflexión para construir una pregunta de enfoque, reclama un análisis para seleccionar los conceptos centrales y sustantivos, requiere que se haga una síntesis al seleccionar los conceptos más relevantes, promueve un proceso de construcción para organizar y relacionar los conceptos, demanda una planeación de la estructura conceptual del tema, exige la interrelación conceptual bajo la elaboración de vínculos entre las ideas o conceptos a partir de la construcción de frases de enlace que expliciten las relaciones pertinentes que estructuran la coherencia entre los conceptos y la congruencia de un planteamiento global, del tema que se está estudiando.

El propósito de este estudio es presentar los resultados de una investigación que se realizó para mejorar el uso de los *mapas conceptuales* en un curso de psicología educativa, que se llevó a cabo con estudiantes que cursaban el 5 semestre de sus estudios universitarios.

La hipótesis de trabajo fue: Si se exhiben (proyectan) en el salón de clases de manera más intensa los *Cmaps* elaborados por los alumnos, su calidad aumenta. La explicación alternativa es que se pone mayor esmero en su elaboración.

2 Marco teórico

De acuerdo con Novak y Cañas (2008), los mapas conceptuales se entienden como herramientas gráficas que son útiles para construir, organizar y representar estructuras de conocimiento de manera lógica, jerárquica y significativa. Para estos autores, un concepto es “una regularidad percibida en eventos u objetos, o registros de eventos u objetos designados por una categoría” (Novak & Cañas, 2008)

El uso de mapas conceptuales tiene su base epistemológica en el planteamiento constructivista de la psicología, cuyo argumento es que el conocimiento no es una mera copia de la realidad, sino más bien una construcción o reinterpretación de dicho conocimiento en la interacción de los individuos con el mundo circundante, cuando se enfrentan situaciones novedosas (Hernández, 1998, 1998).

El planteamiento educativo de los mapas conceptuales proviene de la psicología cognitiva del aprendizaje significativo propuesta por David Ausubel (Ausubel, Novak, & Hanesian, 1983; Ivie, 1998), en la cual se afirma que el aprendizaje significativo ocurre cuando los nuevos conocimientos que adquieren los alumnos, se asimilan de manera “no arbitraria”, a las estructuras de conocimiento ya presentes en el sistema cognitivo de los estudiantes, lo cual no ocurre con el aprendizaje memorístico por iteración (repetición).

Existen diversas evidencias de investigación en psicología cognitiva que demuestran la forma en que las personas desarrollan comprensión y estructuran conocimiento a través de mapas conceptuales (Novak, 2002a, 2010). Por ejemplo, es posible identificar errores conceptuales en las estructuras de conocimiento de estudiantes universitarios (Novak, 2002). Además, se ha encontrado que el uso de mapas conceptuales tiene poderosos efectos sobre el aprendizaje cuando se utilizan como herramienta cognitiva, ya que permiten la persistencia del conocimiento en la memoria, además de su integración para la comprensión y la solución efectiva de problemas (Novak & Musonda, 1991; Novak, 1990, 2002b; Novak, 1991).

La investigación en mapas conceptuales ha culminado en el desarrollo del software Cmap Tools, que sirve para el diseño, planeación e integración de mapas conceptuales, de una forma análoga a cómo se integra texto en un procesador de palabras (Cañas et al., 2004). Este programa de cómputo incluye características que permiten desarrollar un planteamiento con todos sus elementos estructurales (Novak & Cañas, 2008). Lo anterior lo convierte en una excelente tecnología para crear, modificar, compartir y visualizar modelos de conocimiento, la cual ha mostrado su gran utilidad tanto en escenarios educativos como en la industria (Novak & Cañas, 2006).

En relación a lo anterior es importante destacar que algunas posturas del constructivismo sociocultural, consideran que la incorporación de la tecnología tiene alcances promisorios para poder modificar, y mejorar la experiencia educativa (Kozulin, 2000, 2001). El argumento central de dichas posturas, es que la tecnología media la relación de los seres humanos con su entorno, cambiando la naturaleza de sus procesos cognitivos y también de la relación con otras personas y el entorno (Pea, 1997; Perkins, 1997). De esta manera las personas que aprenden articulan sus procesos cognitivos a artefactos culturales (tecnológicos), que los median para de esta manera poder lograr cosas que no pueden lograrse en ausencia de estos artefactos (Salomon & Perkins, 2005). A este conjunto de concepciones ha sido denominado en la literatura de investigación como “cognición distribuida”.

El uso y la elaboración de mapas conceptuales han demostrado su potencia como andamio para mejorar los procesos de construcción de conocimiento de los alumnos. El ayudarse de mapas estimula la Zona de Desarrollo Próximo de los estudiantes, de tal forma que pueden ir mejorando su elaboración al contrastarlos con mapas bien elaborados (Novak & Cañas, 2008).

Además de poder utilizarse como un andamio para estimular los procesos de construcción de conocimiento, los mapas conceptuales integran formas novedosas para representar modelos de conocimiento que pueden tener efectos importantes sobre el aprendizaje. La investigación de Suthers & Hundhausen (2003), aporta evidencia a este respecto, al demostrar que las formas esquemáticas de representación (en la lógica de mapas conceptuales) tienen mayor ventaja en sus efectos en el aprendizaje de los alumnos que las representaciones en forma de matriz y textuales.

En relación al uso de didácticas mediadas por representaciones, recientemente ha surgido una veta de investigación en el desarrollo de software para el aprendizaje colaborativo en las denominadas “herramientas de percepción de grupo” (Group Awareness Tools, por sus siglas en inglés), que sostiene que es posible mejorar el aprendizaje de los alumnos, si se les ofrece información relevante en forma de representaciones visuales de lo que sus compañeros hacen (comportamental), saben (cognitiva), o sobre cómo se relacionan (social) (Buder, 2011). De tal manera que pueda establecerse un “estándar” de desempeño ideal, que permita que los alumnos orienten sus acciones, interacciones, procesos de pensamiento y productos, para alcanzar niveles de desempeño “aceptables” (Jermann & Dillenbourg, 2008).

Lo anterior nos lleva a pensar, que los mapas conceptuales son una forma potente de representar el conocimiento cognitivo (lo que saben o aprendieron) de los alumnos en sus sesiones de clase, orientando de forma directa los procesos cognitivos (el desarrollo y las discusiones de la clase), y de manera indirecta la elaboración de sus productos de aprendizaje, al generarles la expectativa por mantener cierto estándar de profundidad, riqueza y complejidad en la elaboración de sus mapas conceptuales. De esta manera pensamos que pueden proyectarse sistemáticamente en cada seminario los mapas, y valorar si disminuye o aumenta la calidad

de los mismos en distintos puntos en el tiempo al variar la intensidad de su exposición, considerando distintas métricas, por lo que nos planteamos la siguiente hipótesis:

Si se exhiben (proyectan) los *Cmaps* elaborados por los alumnos en el salón de clases, su calidad aumenta porque se pone mayor esmero en su elaboración.

3 Método

3.1 Sujetos:

De los cursos habituales que se dan a estudiantes del quinto semestre de la carrera de psicología, se seleccionaron a 10 alumnos al azar de dos cursos, uno que llamaremos de *baja intensidad* porque se exhibían sólo un *mapa conceptual*, y otro de *alta intensidad* porque se exhibían dos *mapas conceptuales*. En total participaron 20 alumnos en el estudio, 10 por cada grupo.

3.2 Procedimiento:

La *variable independiente* es definida por la *intensidad* (baja o alta) de exhibición de los *mapas conceptuales* elaborados por los estudiantes en el salón de clases, durante las sesiones presenciales del curso de *Desarrollo o Educación* que llevan como parte de sus cursos curriculares de la licenciatura en *Psicología*.

Los estudiantes de ambos grupos tienen a su disposición un aula virtual en plataforma *Moodle*, donde son requeridos a entregar vía electrónica su *mapa conceptual* elaborado para cada sesión, a partir de la lectura correspondiente al curso.

Se selección a dos grupos, uno con baja intensidad (sólo una exposición) y otro con alta (dos exposiciones), de los cuales se eligieron dos sesiones del curso, una correspondiente a la entrega del primer *cmap* en el curso y la otra al último *cmap* enviado (hubo 21 sesiones), de manera que se tenga el elemento de comparación al igualar tanto el contenido temático como el niveles de experiencia (poca – mucha) elaborando *Cmaps*, es decir, la diferencia entre el primer *cmap* y el último después de haber tenido 21 sesiones de ejercitarse la elaboración de mapas conceptuales, lo que es representativo del *valor agregado* o ganancia. En ambos grupos, los 20 estudiantes fueron seleccionados de forma aleatoria, 10 para integrar el grupo de *baja intensidad* y otros 10 para el grupo de *alta intensidad*.

Como la *variable independiente* se consideró la calidad del *mapa conceptual*. La calidad se definió por la intensidad de trabajo empleada en su elaboración, tomando como indicadores el número de conceptos (Num_Conceptos), de enlaces de entrada (EntConceptos), de salida (SalConceptos), de frases de enlace (Num_Frases), de entradas (Ent_Frases) y de salidas (Sal_Frases), que son los indicadores que *Cmaps tool* incluye dentro de sus utilerías.

4 Resultados

Los indicadores se obtuvieron de la base de datos de *Cmaps tool*, y se procesaron en *SPSS (Statistics vs 21)*. Las estadísticas descriptivas para ambos grupos se presentan en las siguientes tablas, el grupo de *baja intensidad* en la tabla 1 y en la tabla 2 el grupo de *alta intensidad*.

Estadísticos descriptivos						
Grupo 1		N	Mínimo	Máximo	Media	Desv. típ.
Primer Cmap	PM_Num_Conceptos	10	6	48	24.40	13.00
	PM_EntConceptos	10	5	47	24.00	14.00
	PM_SalConceptos	10	6	43	23.40	12.00
	PMNum_Frases	10	5	42	21.00	12.00
	PMEnt_Frases	10	5	44	23.50	12.00
	PMSal_Frases	10	5	47	24.80	14.00
Promedios =		10	5.3	45.2	23.5	12.8
Último Cmap	SM_Num_Conceptos	10	24	48	35.40	7.00
	SM_EntConceptos	10	10	45	31.00	10.00
	SM_SalConceptos	10	9	43	26.90	12.00
	SMNum_Frases	10	9	41	22.00	10.00
	SMEnt_Frases	10	9	43	27.00	13.00
	SMSal_Frases	10	10	48	32.10	10.00
Promedios =		10	11.8	44.7	29.1	10.3

Tabla 1

Estadísticos descriptivos						
Grupo 2		N	Mínimo	Máximo	Media	Desv. típ.
Primer Cmap	PM_Num_Conceptos	10	19	29	25.00	3.00
	PM_EntConceptos	10	21	41	29.20	6.00
	PM_SalConceptos	10	10	36	26.70	7.00
	PMNum_Frases	10	11	28	23.40	5.00
	PMEnt_Frases	10	11	32	24.70	6.00
	PMSal_Frases	10	21	40	29.20	5.00
Promedios =		10	15.5	34.3	26.4	5.3
Último Cmap	SM_Num_Conceptos	10	19	118	68.00	26.00
	SM_EntConceptos	10	18	127	69.80	28.00
	SM_SalConceptos	10	18	83	43.00	17.00
	SMNum_Frases	10	18	73	38.10	16.00
	SMEnt_Frases	10	18	83	42.30	18.00
	SMSal_Frases	10	18	127	69.30	28.00
Promedios =		10	18.2	101.8	55.1	22.2

Tabla 2

Al analizar los datos a partir de las medias obtenidas por el Grupo 1 (baja intensidad) y las del Grupo 2 (alta intensidad) en los 6 parámetros ((Num_Conceptos, EntConceptos, SalConceptos, Num_Frases, Ent_Frases y Sal_Frases) que son utilizados como indicativos de la calidad de los *Cmaps*, se observa que todas las medias en la primer entrega (primer *cmap*) son más o menos similares en ambos grupos (23.5 Grupo 1 en promedio, 26.4 Grupo 2), en cambio, en la última entrega (último *cmap*), después de ya haber elaborado 21 *Cmaps* a lo largo del curso, en ambos grupos se aprecia que en todas las medias mejoraron (29.1 en promedio para el Grupo 1, 55.1 Grupo 2).

Ciertamente, por la dispersión de los datos, se observa que en el Grupo 1 hay mayor varianza que en el Grupo 2 en la primera entrega (Desviación estándar 12.8 vs. 5.3 respectivamente), de aquí se puede asumir que el Grupo 1 era más heterogéneo al iniciar el curso, la distancia entre “buenos” y “malos” estudiantes era mayor que en el Grupo 2. Sin embargo, al concluir el curso esto cambia y se aprecia en la última entrega (Desviación estándar 10.3 en el Grupo 1 y 22.2 en el 2), el Grupo 1 conservó relativamente la misma varianza (10.3 vs 12.8), en cambio el Grupo 2 aumento su dispersión (5.3 vs 22.2) (Ver tabla 1 y 2).

Para evaluar las diferencias de las medias considerando la distribución de la varianza, se hicieron análisis de varianza (ANOVA). Al comparar la ejecución que realizaron ambos grupos en el primer *cmap*, se observa que no había diferencias estadísticamente significativas entre los dos grupos, se puede afirmar que eran grupos equivalentes (ver Tabla 3). En cambio, al comparar la ejecución de ambos grupos considerando el último *cmap* que entregaron, se observa que el Grupo 2 obtuvo mejores puntajes en los 6 parámetros, con diferencias que resultan estadísticamente significativa en 3 de los casos a un nivel de $p < 0.001$, en dos de $p < 0.050$ y sólo en uno ellos p es igual a 0.051 (Ver Tabla 4).

ANOVA de un factor (comparación Grupo 1 vs Grupo 2 al inicio)						
Entre grupos al inicio (primer Cmap)	Suma de cuadrados	gl	Media cuadrática	F	.Sig.	
PM_Num_Conceptos	Inter-	1.800	1	1.800	0.019	.891
	Intra-grupos	1686.400	18	93.689		
	Total	1688.200	19			
PM_EntConceptos	Inter-	92.450	1	92.450	0.731	.404
	Intra-grupos	2276.500	18	126.472		
	Total	2368.950	19			
PM_SalConceptos	Inter-	54.450	1	54.450	0.534	.474
	Intra-grupos	1834.500	18	101.917		
	Total	1888.950	19			
PMNum_Frases	Inter-	28.800	1	28.800	0.317	.580
	Intra-grupos	1636.400	18	90.911		
	Total	1665.200	19			
PMEnt_Frases	Inter-	7.200	1	7.200	0.072	.792
	Intra-grupos	1806.600	18	100.367		
	Total	1813.800	19			
PMSal_Frases	Inter-	96.800	1	96.800	0.775	.390
	Intra-grupos	2249.200	18	124.956		
	Total	2346.000	19			

Tabla 3

ANOVA de un factor (comparación Grupo 1 vs Grupo 2 al final)						
Entre grupos al final (último Cmap)	Suma de cuadrados	gl	Media cuadrática	F	.Sig.	
PM_Num_Conceptos	Inter-	5313.800	1	5313.800	14.296	.001
	Intra-grupos	6690.400	18	371.689		
	Total	12004.200	19			
PM_EntConceptos	Inter-	7220.000	1	7220.000	16.078	.001
	Intra-grupos	8083.200	18	449.067		
	Total	15303.200	19			
PM_SalConceptos	Inter-	1296.050	1	1296.050	5.306	.033
	Intra-grupos	4396.900	18	244.272		
	Total	5692.950	19			
PMNum_Frases	Inter-	1155.200	1	1155.200	5.861	.026
	Intra-grupos	3547.800	18	197.100		
	Total	4703.000	19			
PMEnt_Frases	Inter-	1140.050	1	1140.050	4.376	.051
	Intra-grupos	4689.700	18	260.539		
	Total	5829.750	19			
PMSal_Frases	Inter-	6919.200	1	6919.200	15.113	.001
	Intra-grupos	8241.000	18	457.833		
	Total	15160.200	19			

Tabla 4

De aquí que se puede señalar que se confirma la hipótesis de trabajo del estudio, donde se afirma que si se exhiben (proyectan) los *Cmaps* elaborados por los alumnos en el salón de clases su calidad aumenta. Esto se considera que es así, porque los alumnos ponen mayor esmero en su elaboración, sabiendo que serán exhibidos.

Al comparar las medias obtenidas en los 6 parámetros al inicio (primer *cmap* vs último *cmap*) de ambos grupos, se observa que en los dos hubo mejoras, en el Grupo 1 fue una ligera mejoría (23.5 vs 29.1 promedio), pero éstas sólo en un caso (Num_Conceptos) es estadísticamente significativa la diferencia ($p < 0.05$) (ver Tabla 5). En cambio en el Grupo 2 en los 6 parámetros se observan diferencias estadísticamente significativas ($p < 0.050$) (ver Tabla 6), datos que permiten reiterar que aumentar la intensidad de exposición de los *Cmaps* promueve la calidad de la elaboración de los mismos.

ANOVA de un factor (compración pre - post Grupo 1)						
Intra-grupo		Suma de cuadrados	gl	Media cuadrática	F	Sig.
Grupo 1 - baja intensidad						
Num_Conceptos	Inter-grupos	605.000	1	605.000	5.082	.037
	Intra-grupos	2142.800	18	119.044		
	Total	2747.800	19			
EntConceptos	Inter-grupos	238.050	1	238.050	1.512	.235
	Intra-grupos	2834.500	18	157.472		
	Total	3072.550	19			
SalConceptos	Inter-grupos	61.250	1	61.250	0.386	.542
	Intra-grupos	2853.300	18	158.517		
	Total	2914.550	19			
Num_Frases	Inter-grupos	18.050	1	18.050	0.142	.711
	Intra-grupos	2286.900	18	127.050		
	Total	2304.950	19			
Ent_Frases	Inter-grupos	68.450	1	68.450	0.404	.533
	Intra-grupos	3052.100	18	169.561		
	Total	3120.550	19			
Sal_Frases	Inter-grupos	266.450	1	266.450	1.624	.219
	Intra-grupos	2952.500	18	164.028		
	Total	3218.950	19			

Tabla 5

ANOVA de un factor (compración pre - post) Grupo 2						
Intra-grupo		Suma de cuadrados	gl	Media cuadrática	F	Sig.
Grupo 2 - alta intensidad						
Num_Conceptos	Inter-grupos	9245.000	1	9245.000	26.694	.000
	Intra-grupos	6234.000	18	346.333		
	Total	15479.000	19			
EntConceptos	Inter-grupos	8241.800	1	8241.800	19.714	.000
	Intra-grupos	7525.200	18	418.067		
	Total	15767.000	19			
SalConceptos	Inter-grupos	1328.450	1	1328.450	7.079	.016
	Intra-grupos	3378.100	18	187.672		
	Total	4706.550	19			
Num_Frases	Inter-grupos	1080.450	1	1080.450	6.712	.018
	Intra-grupos	2897.300	18	160.961		
	Total	3977.750	19			
Ent_Frases	Inter-grupos	1548.800	1	1548.800	8.094	.011
	Intra-grupos	3444.200	18	191.344		
	Total	4993.000	19			
Sal_Frases	Inter-grupos	8040.050	1	8040.050	19.200	.000
	Intra-grupos	7537.700	18	418.761		
	Total	15577.750	19			

Tabla 6

5 Conclusión

La elaboración de *mapas conceptuales* es un artefacto (herramienta) que favorece la reflexión de los estudiantes, la necesidad de organizar conceptualmente el conocimiento que están aprendiendo, el tener que construir una propuesta evita el plagio en tanto no admite el copia y pega, y ofrece la posibilidad de ser exhibidos por medio de una proyección y de este modo invitar a todo el grupo a revisar y enriquecer al *mapa* que está siendo expuesto, haciendo los ajustes que se consideren pertinentes por consenso.

La dinámica de discurrir en torno a la presentación de un *mapa conceptual* permite el desarrollo del *aprendizaje expansivo*. El grupo no queda restringido a los contenidos de la lectura realizada y que están expresados en el *mapa*, sino se abre la exploración de las ideas que afloran en las reflexiones de los alumnos, dando lugar a rutas de deliberación no trazadas, se trata de que a partir del *mapa conceptual* expuesto se planten argumentos para mejorarlo, dando lugar a que el estudiante que elaboró el *mapa* exponga su contrargumentación en defensa de su propuesta si tiene los elementos, y quedar abiertos a refutación de ideas si es que hay más argumentos. Este proceso promueve la construcción expansiva de aprendizaje, que es uno de los propósitos del diseño educativo del curso.

Para concluir se puede señalar que sería conveniente dotar de herramientas de comunicación a *Cmap Tool* para poder mediar la construcción colectiva del conocimiento expresado en un *mapa conceptual*. Vendría bien dar visibilidad a las acciones de los colaboradores, en tanto concepción epistemológica como la que implica una dinámica de *aprendizaje expansivo*, el conocimiento y el aprendizaje está distribuido y mediado por los otros, el diálogo es una vía que debe ser promovida.

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CMAPIED: UMA PROPOSTA DE AMBIENTE VIRTUAL DE APRENDIZAGEM BASEADO EM MAPAS CONCEITUAIS

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Resumo. Ambientes voltados à aprendizagem têm sido concebidos e disponibilizados para apoiar a educação presencial e a distância. A maioria dessas plataformas opta por organização de conteúdos educacionais em estruturas hierárquicas, sequenciais e instrucionais, de acordo com planejamentos curriculares em forma de cursos, subdivididos em tarefas. Agrega-se a cada tarefa recursos de interação, como elaboração de textos, diários eletrônicos, envio de arquivos, ferramentas de comunicação, participação em fóruns, interação com objetos de aprendizagem, questionários avaliativos e até iniciativas de integração com ferramentas de suporte a Mapas Conceituais. Contrapondo a esse modelo mecanizado, encontram-se iniciativas, conhecidas como Arquiteturas Pedagógicas, voltadas à construção de ambientes flexíveis a partir da combinação de estratégias e de dinâmicas em grupo, com softwares educacionais e ferramentas de cooperação. Este texto apresenta a proposta de um ambiente, denominado CMapped, voltado à aprendizagem por meio da organização de conteúdos didáticos e de atividades cooperativas na forma de Mapas Conceituais. Busca-se demonstrar como usá-lo para o suporte à Arquitetura Pedagógica e a outros modelos educacionais. O mérito e diferencial da abordagem é considerar os participantes como conceitos do Mapa Conceitual, que navegam e interagem simplesmente criando conceitos e relações no mapa.

Palavras-chave: Ambiente Virtual de Aprendizagem, Arquitetura Pedagógica, Mapa Conceitual.

1 Introdução

O crescente uso de Ambientes Virtuais de Aprendizagem na era da Informação e da Internet tem motivado diversas pesquisas sobre como elaborar sistemas para educação à distância e apoio às atividades presenciais. As propostas investigam como teorias de aprendizagem podem ser conduzidas por tecnologias e recentes estudos apontam para correntes de psicologia cognitiva significativa (Ausubel, 1963), interacionista (Vygotsky, 1978) e construtivista (Piaget, 1977).

Ainda que essas diretrizes estabelecidas norteiem o projeto e a elaboração de ambientes virtuais, fazer com que os artefatos informatizados promovam aprendizagens de qualidade é uma iniciativa complexa, visto que existem muitos fatores a serem observados na apropriação das novas tecnologias e das formas de interação voltados à melhoria do conhecimento e do saber. Dessa forma, evoluções e reconstruções de ambientes são bem vindas. Repensar e agregar novas ideias a fim de superar barreiras é o caminho promotor da informática na educação, diante de tantas rápidas transformações tecnológicas.

Objetivo deste artigo é apresentar o Ambiente Virtual de Aprendizagem CMapped. Inicialmente, o sistema se assemelha a um construtor de Mapas Conceituais com interface Web, aliado a algumas práticas das redes sociais. Entretanto, este trabalho também propõe uma inovação nas formas de se organizar e interagir em relação aos ambientes de aprendizagem. No CMapped, trata-se o participante como mais um conceito do Mapa Conceitual e a navegação pelo ambiente se dá pelas relações entre os conteúdos ou entre os integrantes. É realizada uma breve revisão sobre ambientes de aprendizagem, a fim de relatar os desafios atuais. Após, é apresentado o funcionamento básico do CMapped e a arquitetura de software utilizada. A hipótese é que com o sistema pode-se encontrar alternativas para os desafios apresentados. Além disso, são expostos dois exemplos de aplicação do ambiente para apoio à aprendizagem: (1) como um recurso para atividades presenciais; (2) como uma plataforma para apoio à Arquitetura Pedagógica, um recente conceito que preza por pedagogias abertas em Ambientes Virtuais de Aprendizagem.

2 Ambientes de Aprendizagem

Há uma quantidade significativa de ambientes virtuais que oferece suporte a estruturação de cursos para ensino, com formato subdividido em disciplinas na forma hierárquica e sequencial. Criam-se grupos ou turmas de alunos com a proposta de realizar educação à distância, apoio às atividades não presenciais ou repositório de material didático para aulas presenciais. Encontram-se nessas plataformas alguns instrumentos dinâmicos, como jogos interativos, instrumentos de avaliação, como questionários, e meios de comunicação, como chat e fóruns. Uma característica dessas propostas é o incentivo da participação dos alunos por meio da interação com as ferramentas, demandando do aprendiz proatividade e maior autonomia. O suporte informático auxilia os

professores a se organizarem, a trabalharem com diversas mídias, como figuras e vídeos, a alcançarem um maior número de alunos com acessos em diferentes tempos, promovendo uma educação continuada.

Listam-se alguns sistemas com essas características: Moodle¹, Blackboard², Claroline³, Sakai⁴. Vários outros sistemas similares, em diversos países, foram propostos. Apesar dos benefícios computacionais, pode-se dizer que essas plataformas induzem os professores a seguirem planejamentos pedagógicos de aprendizagem mecânica (Novak & Cañas, 2006), uma vez que os ambientes orientam para exposição de conteúdos e de exercícios investigativos, fazendo com que os alunos tenham uma postura de fixação e de repetição, além de pouco incentivo ao trabalho com incertezas.

Diferente desse contexto, ambientes flexíveis para apoio às inovações pedagógicas abertas tem sidos trabalhados no projeto Morfeu (Menezes et al. 2008; Rangel et al. 2009; Rangel, Cury & Menezes 2011; Natalli & Menezes 2012) e objetivam planejamentos mais interacionistas e construtivistas, principalmente para o apoio às Arquiteturas Pedagógicas (ver Seção 4.2), um novo modelo para se trabalhar com ambientes virtuais. No entanto, os sistemas possuem algumas dificuldades, principalmente relacionadas aos esforços de entendimento das configurações, dos componentes internos e do comportamento dos sistemas perante esses dois itens.

2.1 O uso de Mapas Conceituais

A tecnologia tem sido um instrumento importante para a construção de Mapas Conceituais, como um facilitador ferramental. Por meio da computação, é mais fácil agregar aos conceitos imagens, vídeos, páginas e outros arquivos (Novak, 2010). Dessa maneira, há um esforço na adoção, integração ou adaptação desses artefatos para Ambientes Virtuais de Aprendizagem.

Alguns softwares têm sido distribuídos e amplamente utilizados para atividades educacionais: CMapTools⁵, Compendium⁶ e IVA LMS⁷. De acordo com a proposta desses ambientes, ferramentas de sincronização e comunicação entre os participantes adicionam a solução formas para que os alunos e professores compartilhem e colaborem os Mapas Conceituais (Cañas et al., 2004). Entretanto, o que fazer com o conhecimento produzido durante as comunicações entre os participantes, por exemplo, na conversa do chat? Todas essas interações são visualizadas somente observando o mapa? Para um professor ou aluno ter acesso a essas informações, ele deverá sempre recorrer às ferramentas auxiliares.

2.2 Desafios a superar

O ambiente compartilhado da Web permite a aprendizagem cooperativa, desde que organizada e planejada. O uso de Mapas Conceituais pode auxiliar nesse processo, estimulando a capacidade de investigar, de analisar, de sintetizar e de correlacionar informações. Em resumo, as iniciativas para adoção de Mapas Conceituais em Ambientes Virtuais de Aprendizagem seguiram dois caminhos: (1) como uma atividade, ou seja, a construção do mapa em ferramenta externa (CMapTools) e publicação como um conteúdo, igualmente a outros materiais do ambiente; (2) construir ferramentas completas de edição de mapas e incorporar nesses sistemas outras formas de comunicação. Nos dois casos, há conhecimento adicional além do mapa. Não seria interessante centralizá-lo?

3 Proposta do Ambiente CMapped

O objetivo desta seção é apresentar as principais ideias de um ambiente de aprendizagem baseado em Mapas Conceituais, denominado CMapped. O mérito e diferencial da abordagem é considerar os participantes como Conceitos do Mapa Conceitual, que navegam e interagem simplesmente criando Conceitos e Relações no mapa. Pretende-se com essa característica correlacionar o conhecimento, manifestado em formatos multimídia, aos participantes, seja professores ou aprendizes, de forma que as atividades comunicativas e cooperativas sejam organizadas e registras pela própria construção dos Mapas Conceituais.

¹ <http://moodle.org/>

² <http://www.blackboard.com/>

³ <http://www.claroline.net/>

⁴ <http://sakaiproject.org/>

⁵ <http://cmap.ihmc.us/>

⁶ <http://compendium.open.ac.uk/>

⁷ <http://www.htk.tlu.ee/iva/>

3.1 Funcionamento básico

Do ponto de vista da interface humano computador, o CMapped é um construtor de Mapas Conceituais em que os conceitos podem ser textos, hipertextos, figuras, vídeos e outros conteúdos multimídias. Para cada conceito pode-se trocar a fonte, a cor do fundo, a borda e outras opções visuais. Do mesmo modo para as relações. Logo, optou-se por um sistema Web (ver Seção 3.2). É baseado em layouts de maneira não intrusiva, para que se possa trabalhar com conceitos e relações, semelhante a outros sistemas, por exemplo, o CMapTools. No entanto, possui algumas regras que o difere dos demais. Para um melhor entendimento, seja um Mapa Conceitual uma estrutura de dados na forma de grafos. Um conceito é um vértice e as arestas são as relações entre os conceitos. Assim como em teoria dos grafos, os vértices podem ser coloridos, ou seja, ter tipos de vértices. Para o CMapped, os conceitos são categorizados em tipos, por exemplo, uma figura é um tipo e um vídeo é outro tipo.

O ponto principal é que um participante do sistema também será um tipo de conceito. Ao se cadastrar no sistema, cria-se o conceito. Este conceito será iniciado com o caractere “@” a frente do nome. Após a entrada no sistema, são exibidos todos os conceitos relacionados ao conceito do participante, mostrados na interface como um grande mapa, em que é possível ampliar e navegar com o mouse. Para todo conceito criado por ele possuirá também versões a cada modificação, guardando-se o histórico de edição. As interações do participante no CMapped manifestam-se pelo uso do mapa, criando relações entre os conceitos (arrastar e soltar) e por uma caixa de ferramentas, como mostra a Figura 1, explicada nos próximos parágrafos pelos destaques nela enumerados.

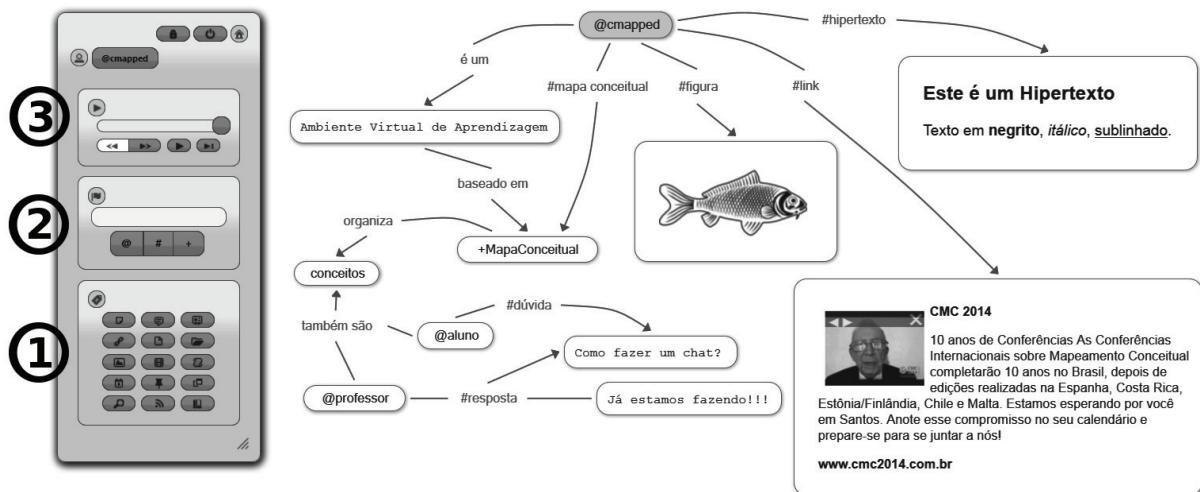


Figura 1. Visão geral do Ambiente CMapped e destaque a explicar

Um conceito é adicionado ao mapa por meio de um clique nos ícones da Caixa de Seleção de Conceitos (Destaque 1 da Figura 1), em que cada ícone é um tipo de conceito. O primeiro ícone é a adição de um conceito do tipo palavra, em que é permitida somente uma palavra (sem espaços). Ele é útil quando se deseja adicionar outro mapa ao contexto, bastando iniciar a palavra com o caractere “+”, ou seja, um usuário poderá fazer quantos mapas quiser, bastando criar conceitos dessa forma. Ao se clicar neste conceito, abre-se um novo mapa e neste também poderão se adicionar novos mapas da mesma forma. Isso é útil para delimitar o escopo de um curso para os professores, sendo possível navegar entre os mapas. Então, quando um participante é criado, além do conceito a ele atribuído, tem-se o mapa associado a este conceito.

Quando se deseja adicionar outro participante a qualquer mapa, basta criar um conceito palavra e iniciá-la com o caractere “@”. Uma caixa de pesquisa é aberta para pesquisa de outros participantes. Se o participante estiver online, o conceito será colorido ou branco do contrário. Este novo participante adicionado poderá criar conceitos no mapa. No entanto, para ele visualizar os outros conceitos do mapa é necessário criar uma relação com algum conceito pré-existente. Isso é útil quando se deseja ocultar informações. Criada a relação, será visto por ele somente os conceitos que possuem um caminho até o conceito (teoria dos grafos). Para que o conceito seja editado também pelo outro participante, coloca-se o “@” também na relação (aresta). Essa é uma maneira fácil de compartilhar e permitir cooperação entre os participantes.

Da mesma forma, outro caractere importante é o “#”. Ao iniciar um conceito palavra ou relação com esse, será como dizer ao CMapped que isso terá um destaque no Mapa. Com esse recurso, pode-se filtrar a exibição dos termos que possuem o caractere ou não (Destaque 2 da Figura 1), o mesmo vale para o “@” e o “+”. Caso o item seja selecionado, oculta ou exibe os conceitos, além de ser possível criar critérios de filtro (Figura 2). Por

exemplo, quando se quer exibir ou ocultar somente os conceitos e relações com “#mapa” ou conceitos dos participantes que iniciam com o nome “@aluno”. Caracteres curingas ajudam a delimitar o filtro, como os comumente usados “*” (para zero ou mais) ou “?” (para um ou mais).

Em ambientes de aprendizagem é desejável que se possam reaproveitar conteúdos. Portanto, cada conceito possui um ícone de cópia, que ao clicar copia-se o conceito, mas desfazem as relações (cria-se a relação com o participante que copiou). O conceito pode ser adicionado a outro mapa, com o recurso arrastar e soltar. Além do conceito palavra, foram desenvolvidos na versão inicial quatorze outros tipos: texto, hipertexto, link, arquivo, pastas e arquivos, figura, vídeo, scripts (javascript, applet, flash), calendário, mapa geográfico, janela, pesquisa avançada, disseminação e relatórios. Esses três últimos lidam com funções requeridas em qualquer ambiente virtual, por exemplo, quando se quer exibir conceitos de outros mapas segundo critérios (pesquisa avançada), quando algum evento ocorrer (disseminação) ou quando se quer extrair informações padronizadas e organizadas (relatórios). Tais opções são úteis e necessárias principalmente quando um professor quiser realizar avaliações.

Nos conceitos do tipo script pode-se propor a utilização de objetos de aprendizagem, geralmente feitos com extensões de tipos executáveis (flash e applet). Novas opções de conceitos somente são possíveis se uma nova versão do sistema for desenvolvida (ver Seção 3.2), diferente de outros ambientes que permitem adição de ferramentas com o sistema em funcionamento. Apesar de isso ser útil, algumas ferramentas podem deixar os sistemas vulneráveis e instáveis. Ainda assim, em trabalhos futuros deve-se estudar essa possibilidade (ver Seção 5). Um pré-requisito para tal fato já fora pensado, em que cada tipo de conceito possui um metadado que descreve as informações geridas, por exemplo, nos arquivos guarda-se a informação da versão enviada.

Além dessas funcionalidades, um recurso importante para o processo de avaliação é o histórico de versões (Destaque 3 da Figura 1) de um mapa. Aliado as ferramentas de filtro (Figura 2), pode-se saber exatamente qual foi o processo de construção e reconstrução do mapa de cada participante, sendo um importante mecanismo de acompanhamento do processo cognitivo do aprendiz. Não obstante a essas facilidades, fazer com que todos os elementos estejam sincronizados é uma atividade computacionalmente complexa. Para tanto, uma arquitetura de software, apresentada a seguir, atende de forma satisfatória a esse funcionamento básico.

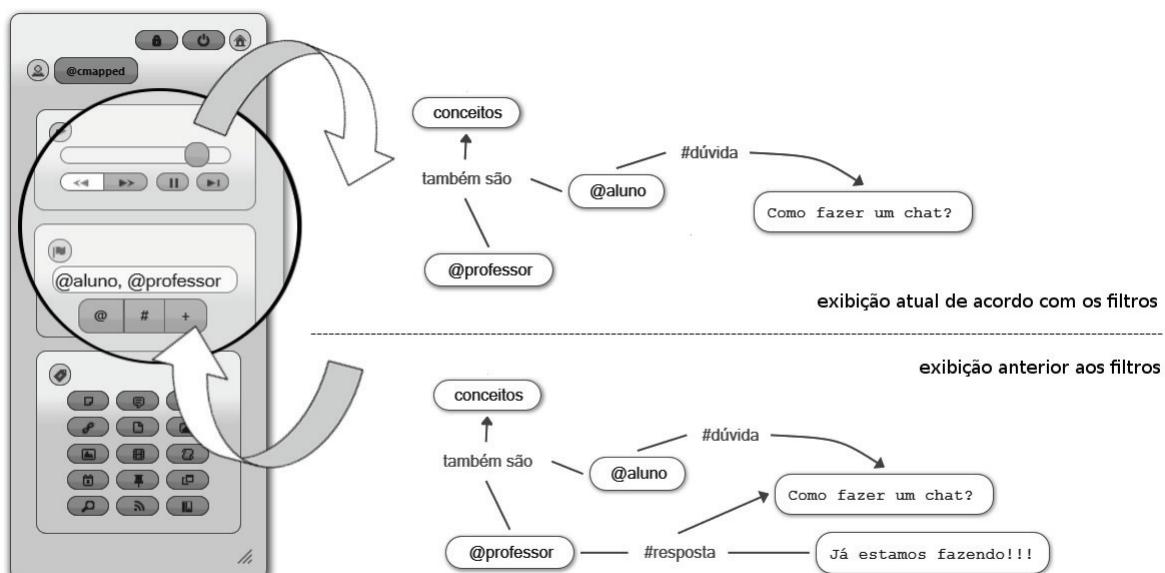


Figura 2. Histórico de versões e Filtro do CMaped

3.2 Arquitetura de software

Do ponto de vista da interface hardware e software, o CMaped é um sistema Web baseado em um modelo cliente-servidor em três camadas segundo o padrão modelo-controle-visão, comum aos ambientes voltados à Internet. Usa-se para a camada de interface no cliente (navegador Web) as tecnologias jsPlumb⁸, para o desenho

⁸ <http://jsplumbtoolkit.com/>

do Mapa Conceitual, e jQuery⁹, para outros controles. De tempos em tempos e para cada alteração no Mapa, requisições do tipo Ajax¹⁰ são enviadas para servlets da tecnologia Java Server Faces¹¹ no servidor de aplicação, que faz a sincronização e persistência das alterações por meio de um framework orientado a grafo Titan¹². O Titan permite a utilização de banco de dados distribuídos, como a tecnologia Apache Cassandra¹³. O Titan ainda fornece interfaces de navegação e manipulação dos grafos por meio do framework TinkerPop¹⁴. Os arquivos são indexados usando o framework Apache Lucene¹⁵. Todas essas tecnologias são de código aberto e livre, assim como o CMapped. Detalhes da arquitetura, instalação e pré-requisitos de hardware podem ser encontrados na página do CMapped¹⁶.

3.3 Comparações com outros ambientes

Em relação aos ambientes de aprendizagem organizados segundo uma arquitetura hierárquica e mecanizada, o CMapped apresenta-se como uma alternativa para construções cognitivas mais significativas para os aprendizes por meio da organização de conteúdo em Mapas Conceituais. Para professores e educadores, há uma gama maior de potencialidades para planejamento, organização e execução das atividades psicopedagógicas (ver Seção 4). Em ambientes hierárquicos, diferentes matérias e disciplinas são esparsas pela organização sequencial, como em livros didáticos. Nesse contexto, a interdisciplinaridade pode não ser clara aos aprendizes, que podem ter dificuldades em correlacionar conteúdos e domínios. O uso de Mapas Conceituais para orientar os conteúdos é um facilitador nesse processo, em que o plano de ensino pode seguir caminhos mais adequados à concepção do professor ou da melhor apropriação do aluno, de acordo com a navegação pelos mapas, e não mais rígido como o imposto pela sequência capítular dos ambientes hierárquicos ou dos livros.

Em relação às propostas de ambientes baseados em Mapas Conceituais, como CMapTools, Compendium e IVA LMS, o CMapped, além de propor uma arquitetura e navegação Web, também diferencia-se na proposta de tratar os participantes como conceitos do Mapa, em que as relações estabelecem as formas de comunicação e de cooperação na ferramenta. Utilizando-se de regras baseadas em teoria dos grafos, podem-se solucionar questões como acesso, exibição e recuperação dos conteúdos, ainda que tal característica requeira explicações de como a teoria se comporta no ambiente, o que é normal de todos os softwares. Os outros ambientes se utilizam de funcionalidades de comunicação e de coordenação para tratar esses assuntos, o que é válido, porém, e o conhecimento produzido nessas interações? O que é comunicar-se? O que é um chat? O que é um fórum? O CMapped considera que toda forma de conhecimento tenha que ser mapeado no ambiente, como demonstrado na Figura 2.

Em relação às propostas de ambientes flexíveis de organização de conteúdo, como o projeto Morfeu, o CMapped pode ser considerado também um ambiente flexível, no entanto, ignora-se o conceito de espaços virtuais planejados e configuráveis (veículos de comunicação), que são instanciados em seções para suportar a criação e operação de Arquiteturas Pedagógicas (ver Seção 4.2). No CMapped, uma Arquitetura Pedagógica pode ser modelada como um Mapa Conceitual, as instanciações são cópias do mapa e a operação ocorre criando conceitos e relações com os aprendizes, no momento oportuno, dirigido e orientado pelo professor. Nesse ponto, o CMapped é ainda mais flexível às necessidades e às percepções do educador. Portanto, este trabalho propõe que metodologias abertas e diferenciadas de aprendizagem possam ser modeladas e remodeladas, discutidas e cursadas pelo próprio ambiente, se utilizando de Mapas Conceituais como facilitador desse processo.

4 Apoio à Aprendizagem

Aplicações de Mapas Conceituais no contexto educacional são amplas, comumente associadas a apoio: (1) às atividades didáticas para planejamento e orientação de disciplinas pelo professor; (2) ao uso como artefato cognitivo pelo aluno por meio de exercícios de construção e reconstrução de Mapas Conceituais a partir das experiências anteriores e novos conceitos aprendidos, auxiliando o raciocínio, a crítica e a organização da aprendizagem; (3) à publicação e debate do entendimento comum entre alunos e professor; (4) ao instrumento de avaliação do professor perante a evolução e construção dos conceitos pelos aprendizes. No CMapped esses

⁹ <http://jquery.com/>

¹⁰ <http://ajaxpatterns.org/>

¹¹ <http://javaserverfaces.java.net/>

¹² <http://titandb.io/>

¹³ <http://cassandra.apache.org/>

¹⁴ <http://www.tinkerpop.com/>

¹⁵ <http://lucene.apache.org/>

¹⁶ <http://www.cmapped.org/>

objetivos podem ser trabalhados, inerente a capacidade de construção de Mapas Conceituais. Além desses propósitos, destacam-se dois recursos observados a primórdio, como o apoio às atividades didáticas presenciais e às Arquiteturas Pedagógicas, tratados nas seções seguintes.

4.1 Recurso didático presencial

Nas atividades presenciais de sala de aula, comumente os educadores se utilizam de práticas expositivas e ou de explicações introdutórias, como uma atividade de palestra. Às vezes essa tarefa é delegada aos alunos, quando da apresentação de pesquisas e de trabalhos. Nesse momento, é comum ao palestrante usar de softwares de apresentação, com uma sequência de telas em projetores multimídia. A atenção do aluno permeia entre a fala do palestrante e as exibições de cada tela. Para se associar o que está sendo falado com o que já fora apresentado requer dos espectadores alta memória visual de curto prazo e rápida memória operacional (Miller, 1956). Essas podem sofrer interferência de distrações; de cansaço pelo esforço repetitivo de realizar ao mesmo tempo e em curto espaço pequenas recordações e interpretação de novas informações; além do desinteresse, caso a condução do expositor seja prolongada (Balcells & Martin, 1985).

Desse modo, por iniciativa deste trabalho, propõe-se a utilização do CMapped para exposição presencial, por meio da ferramenta de exibição do histórico de versões (Figura 2), em que o palestrante pode fazer o Mapa Conceitual, em momento anterior ou durante a apresentação, e reproduzir passo a passo o raciocínio. Para os ouvintes, todo o conteúdo estará ligado, facilitando recordar e memorizar o que lhe é exibido. Pode-se também solicitar a participação dos alunos na construção do mapa, o que é desejável para uma prática construtiva e sócio-interativa. Por exemplo, desde o crescente uso de computadores pessoais, celulares e computadores móveis, até a realidade de Um Computador por Aluno ou em laboratórios de informática, pode-se permitir o acesso dos alunos ao mapa em tempo real e esses cooperativamente apoiarem a construção do mapa, com certezas provisórias, dúvidas e pesquisas em fontes de conteúdo (artigos, páginas de internet).

4.2 Apoio à Arquitetura Pedagógica

O conceito de Arquiteturas Pedagógicas tem sido explorado no contexto educacional (Carvalho, Nevado & Menezes, 2005; Fagundes et al., 2006; Carvalho, Menezes & Nevado, 2007; Menezes, Nevado & Dalpiaz, 2009; Nevado, Menezes & Vieira Júnior, 2011). Resumidamente, uma Arquitetura Pedagógica é um modelo que se inicia na elaboração de propostas pedagógicas embasadas (perspectivas piagetianas) com metas, planejamento e articulação. Após, define-se quais formatos de conteúdo irão se trabalhar. Traçam-se quais serão as atividades de cooperação e a ordem cronológica, os papéis dos professores e aprendizes em cada atividade e os processos de avaliação. Por último, verifica-se qual plataforma tecnológica é possível de suportar o modelo.

Ressaltam-se algumas Arquiteturas expostas pelos autores citados: Projeto de Aprendizagem, Estudo de Caso ou Resolução de Problema, Aprendizagem Incidente, Trilha Virtual, Ação Simulada (Júri Simulado), Debate de Teses, Construindo Conceituações (Quadro Cognitivo). Uma Arquitetura Pedagógica pode ser vista como uma referência ou guia para prática educacional, distanciando-se do modelo mecanizado. Por exemplo, sejam resumidamente as atividades de um Projeto de Aprendizagem: (1) professores e estudantes definem projetos de pesquisa; (2) os alunos se organizam em grupos livremente de acordo com curiosidades e interesses; (3) cada grupo seleciona uma “Questão de Investigação”; (4) estudantes realizam um inventário dos conhecimentos sobre a questão; (5) o conhecimento é classificado em “certezas provisórias” e “dúvidas temporárias”, com objetivo de esclarecer as dúvidas e validar as certezas; (6) os estudantes publicam os progressos no “Diário do Projeto”; (7) professores acompanham o trabalho, fornecendo suporte para correção de rumos e superação de dificuldades; (8) os visitantes do projeto postam comentários, votam nas enquetes e participam dos fóruns criados pelos estudantes; (9) estudantes se reúnem no ambiente para discutir e tomar decisão sobre o andamento do projeto; (10) professores avaliam e comentam as versões do projeto.

As atividades do Projeto de Aprendizagem necessitam de requisitos telemáticos quanto a inventários, sites pessoais, diários, comentários, enquetes e fóruns em ambientes virtuais de aprendizagem. No entanto, esses elementos precisam estar dispostos de maneira organizada em espaços e disponibilizados somente em momentos oportunos. De acordo com o relato dos autores, a adaptação de ambientes hierárquicos, como o Moodle, nem sempre atendera as demandas satisfatoriamente e requeriam adaptações no código do software. Nesse contexto, foram apresentadas várias propostas de ambientes flexíveis para suportar diferentes arquiteturas, decorrentes do projeto Morfeu. Basicamente esses trabalhos sugeriram espaços virtuais remodeláveis, chamados de veículos de comunicação. Os veículos trabalhariam com a mesma unidade de produção de conteúdo, que suportaria vários tipos de formatos multimídia, diferenciando-se na organização do espaço, por exemplo, por ordem de postagem. Etapas, grupos e papéis também seriam definidos no veículo e dessa forma esse suportaria a instanciação de

uma Arquitetura Pedagógica. Por exemplo, um Projeto de Aprendizagem pode ser modelo como (Figura 3): Desenvolvimento do Projeto, Diário de bordo, Fórum de orientação e Livro de visitas.

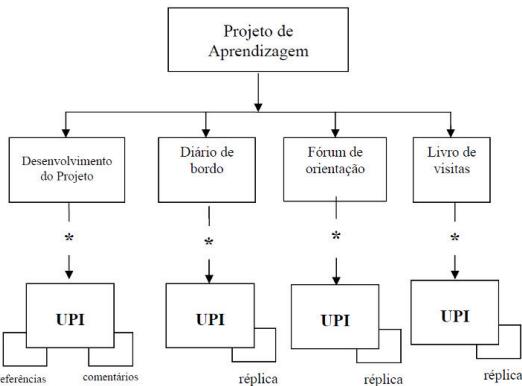


Figura 3. Visão de um Projeto de Aprendizagem no projeto Morfeu (Menezes et al. 2008)

Apesar de se atingir o propósito quanto à Arquitetura Pedagógica, para que os participantes possam usufruir dessa capacidade nesses ambientes é necessário esforços de entendimento das configurações, dos componentes internos e do comportamento dos sistemas perante esses dois itens, ou seja, o planejamento de um veículo de comunicação pode ser não trivial para iniciantes em informática. Propõe-se, por iniciativa deste texto, que no CMapped pode-se modelar uma Arquitetura Pedagógica na forma de um Mapa Conceitual, em que todos os elementos estariam explicados e relacionados, o que facilitaria o entendimento do que é para ser feito. Além do modelo, as atividades da Arquitetura Pedagógica podem ser novos mapas, em que se pediria aos aprendizes interações com os conceitos e relações dos outros participantes (Figura 4). A ordem cronológica pode ser controlada à medida que o educador libera os mapas para edição. Portanto, o CMapped é mais permissivo que os ambientes do projeto Morfeu, mas oferece apoio à Arquitetura Pedagógica de um jeito simplificado.

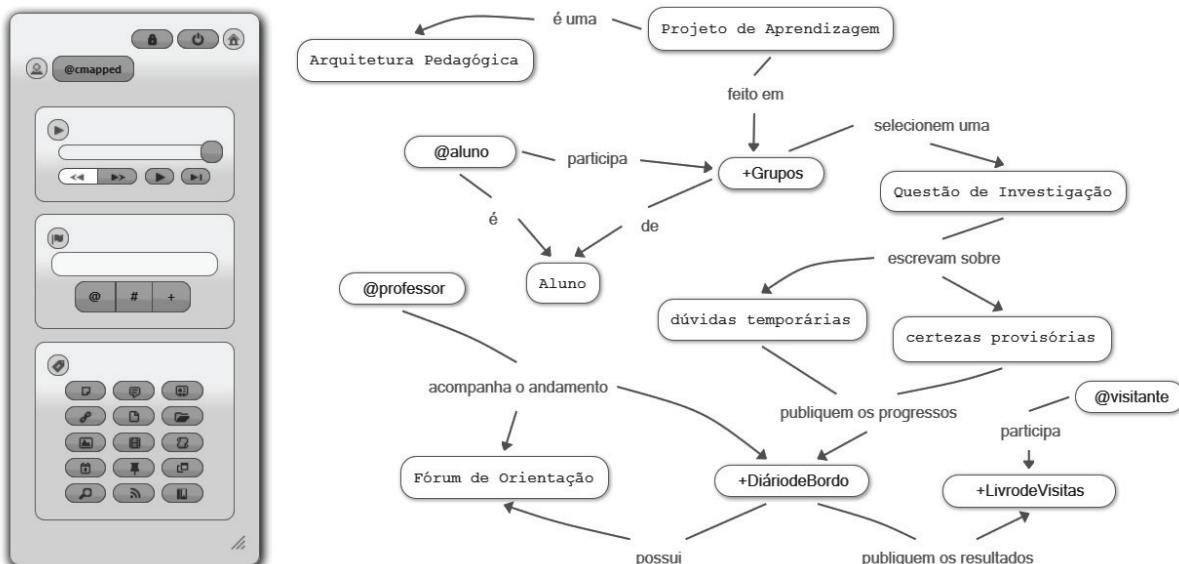


Figura 4. Visão de um Projeto de Aprendizagem no CMapped

5 Conclusão e trabalhos futuros

Este artigo teve como mérito apresentar o CMapped e algumas aplicações do sistema. Como versão inicial, funcionalidades podem ser adicionadas ou revistas. Alguns recursos poderiam potencializar ainda mais a prática na educação, como análise e comparação de mapas, o uso de videoconferências, geração automática de mapas a partir de textos e de páginas e também propostas de inteligência artificial, como agentes e mineração de dados.

Porém, a principal necessidade e os próximos passos são quanto à verificação e avaliação do ambiente em estudos de casos e relatos de experiências. Portanto, este artigo pretende ser um motivador para novos campos

de pesquisa e de trabalho, sendo essa a contribuição esperada. O sistema encontra-se em fase experimental, o que classifica o trabalho como proposta, no entanto, dados preliminares deverão ser divulgados em futuros trabalhos, demonstrando a viabilidade de uso, as limitações técnicas e o incentivo para adoção, contribuição e evolução pela comunidade.

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CMPAAS – A PLATFORM OF SERVICES FOR CONSTRUCTION AND HANDLING OF CONCEPT MAPS

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Abstract. Concept maps are popular today and they have been used to support different activities, where knowledge needs to be organized and represented, particularly in learning activities, either in academy or in the corporate world. However, they are not used as they should for different reasons. In this paper we have pointed out some of those reasons and we also present an environment that, we believe, has a great chance to be a good solution. That environment consists of a service-oriented platform whose objectives are: transforming academic works in affordable computer services to the community in general and provide mechanisms that allow the community to create, extend and integrate new services or functionalities to the proposed platform.

Keywords: concept map, portal of knowledge, platform of service.

1 Introduction

Concept maps have been used in several educational activities that comprise teaching and learning. In fact, their applications are being explored and have shown advantages both, in planning pedagogical activities (Hartmann *et al.*, 2014), and in the monitoring and assessment of learning (González, 2001). Likewise, they have been used as a tool for organizing and building knowledge, regardless of the domain of application. More recently it began to be used as a tool for knowledge representation in a way that can be computationally interpreted or processed (Cañas *et al.*, 2000, 2008).

We agree with Novak & Gowin (1984) who define a concept map as a graphical tool to represent and organize knowledge in two dimensions, using concepts distributed in such a way that the relations between them are evident. On a map, the concepts are nouns and the links are verbal structures. Each triple (concept, connection, concept) forms a semantic unit, the smallest unit of information present in a concept map, which we call proposition. The propositions constitute the basic feature of concept maps, which distinguishes them from other similar representations (Dutra *et al.*, 2007).

Novak supports his definitions on the basis of Ausubel's Meaningful Learning Theory (Ausubel, 1968). According to this cognitive theory, a mental structure of knowledge is hierarchically organized, in a tree like shape, where concepts that are more general are at its highest levels, near the root, while concepts that are more specific are at lower levels.

Concept maps are popular today and are used to support different activities, in which knowledge needs to be organized and represented (Gava *et al.*, 2003), particularly in education (Dutra *et al.*, 2004). In human activities, we are driven by the curiosity to know the similarities and / or differences between concepts. We are also led to compare, generalize and even to merge or generate them automatically. However, if we assume a constructivist approach, we can bring some issues to this trend of computerization and automation: is meaningful learning aided by this technology? Will the available resources contribute to true improvement of the mechanisms of assimilation and accommodation of knowledge? (Souza *et al.*, 2007).

If we think of tools to support education, the maps herein are milder to the use and understanding. Countless times does a teacher make use of maps to check the level of understanding of the student for a given topic or wants to see the average knowledge of a classroom. If the maps are automatically generated, the teacher can refer to them to assess their fidelity to the domain or text that gave rise to them. Through a map editor, he/she can add or undo constructs with great ease. When learners work in small groups and cooperate to learn a given subject, they achieve favorable cognitive and affective outcomes.

Among a huge number of applications, concept maps help students learn more meaningfully help teachers to indicate visually key concepts and summarize their interrelationships, and also assist groups in collaborative tasks. In the latter case, they aid communication between team members and in the management of project development. Concept maps also facilitate the understanding of the subject by each learner.

However, the academy is not the only sector of society interested in applications and tools aimed for editing, manipulation and analysis of concept maps. In business, there is also great interest in the creation and use of these tools. As an example, there was a considerable increase in the production of computational tools for the automatic construction of maps, directly from data sources such as unstructured texts. In fact, most of the approaches (10 out of 15) to automatically constructed concept maps were published in the last three years (Kowata *et al.*, 2009).

Since concept maps motivate both, industries and the academy, what prevents the most rapid development of research and technological solutions in this domain? Two possible problems affect both, the academy and corporations, thus requiring efforts to minimize them: (i) fragmentation of the research and, consequently, (ii) limitation in their evolution and application .

By “fragmentation of research”, we mean a real separation between the solutions developed, sometimes even done by the same research lab. Let us take, for example, the following solutions: an automatic generator of concept maps (Kowata *et al*, 2010), an environment for building and versioning concept maps (Santos *et al*, 2005), an environment for automatic evaluation of concept maps (Gava *et al*, 2003), a tool for comparing concept maps (Lamas *et al*, 2005), and a solution to increase the cohesion and coherence in concept maps (Ribeiro *et al*, 2011). All these studies were carried out by the same laboratory, and culminated in the creation of technological tools that assist, each one in its specificity, the use of concept maps. However, despite having points in common, the tools developed by these researchers are not able to communicate, i.e., do not compose a set of tools capable of defining a complete solution to support the use of concept maps. Therefore, since they are not integrated, they become inaccessible to general users who usually want to perform different tasks with concept maps.

In the same context of research fragmentation, Lourenço (2008) presents an approach to the analysis and evaluation of conceptual maps. In his work, it is possible to envisage a number of computational tools that can assist the author in the data collection process and in the composition of the statistics presented. However, the development of such tools may not be feasible because it might require the development of a complete environment, with user authentication, a system for the managing and editing of concept maps etc. Since the studies tend to be too fragmented, their development and reuse call for reconsideration. The practical result of this fragmentation is observed when pedagogical approaches based on concept maps are put in practice. In some cases, there are no computational solutions that help teachers in their analyses and assessments, whether statistical or cognitive, bringing about a heavy load of cognitive and manual processing.

An equally serious problem is the fact that the community in general and the academy seem not to be speaking the same language. After all, why does the community in general have so much difficulty in accessing the research and their results fast and easily? We consider it important to create a mechanism to facilitate the access to the results of scientific research, so that the community can contribute to their evolution. What we propose, thus, is launching the bases towards a closer interaction between the academic world and society in general.

Therefore, in this study we emphasize the need for adoption of development techniques to facilitate the reuse of existing results in the short term. For this, we propose the creation of a service-oriented platform whose objectives are: (i) transforming academic works in affordable computer services to the community at large and (ii) provide mechanisms that allow the community to create, extend and integrate new services or functionalities to the proposed platform.

For the presentation of this platform, this paper is organized into four sections. The first aims to present the context of the problem as well as the organization of the article. The second aims to present the main features of the concept maps. The third section provides a description of the architecture of the proposed platform. Finally, the fourth section presents some conclusions and points to possible future works.

2 Why Concept Maps?

From experience we can state with a high degree of certainty that there are countless contexts in which concept maps may serve as a very useful tool. In general we start from a text to obtain an its equivalent map. However, we can also do the opposite, i.e., go from a map to generating a text. It is clear that the maps do not replace texts

but are a good start to their construction. From a single map, various texts can be generated, depending on the view and interpretation of each reader.

We are interested in exploring and enhancing the many positive characteristics we observe in concept maps. In Table 1, we list some general advantages of the maps in relation to the text in different contexts.

Table 1: Common uses of concepts maps.

General Characteristics	Areas of Use	
	Teaching-Learning	Global Community
They are easy to read and construct.	They show the meaningful relationships between the concepts of a lesson, a unit of study or a course.	Maps allow to record meetings minutes.
They soften the process of making tacit knowledge explicit by not requiring very strict formats (grammar).	They represent the conceptual frameworks being discussed in an organized manner, facilitating the presentation and learning of these structures.	Maps allow for the organization of the knowledge of a company or any other institution.
They help students learn how to learn, i.e., that learning builds, corrects and expands prior knowledge.	They work as a short term memory, reminding the teacher and the student of the key concepts, their relationships.	Maps allow indexing concepts, among other tasks.
They enhance the retrieval of information and its application in new contexts.	They allow for recording information.	Maps can replace organograms reasonably well, allowing both, for the structuring of a team, as well as the establishment of subordination and responsibility for each of the members.
They are Non-sequential	They can be used to identify the student's prior knowledge and relate it to new knowledge.	
They help indicate that problem solving usually requires the organization of knowledge relevant to the problem.	They help students and teachers to identify malformed concepts, especially when students work in groups.	
They allow students to feel free to build, reinvent, receive and respond to challenges as well as expressing their inner world.	For involving collaborative learning, they enable: 1) students ,both, individually, and as a group, to observe and analyze the articulation, organization and critical evaluation of the whole process of knowledge construction; 2) teachers to monitor and evaluate the progress of each student's knowledge and of a working group, by observing their maps.	

We also highlight concept maps application in early childhood education, when they are suitable for children with difficulties in constructing sentences. And, because they are ludic, they encourage and facilitate them to express their ideas.

3 CMPaaS: The platform

When dealing with the development of computational solutions, the subject in vogue in recent years is undoubtedly cloud computing. This is a computing model in which processing, storage and computing solutions (software) are offered by a service provider accessed remotely via internet. This technology allows the use of applications and the retrieval of information from anywhere, from any platform, at any time, using the web instead of locally installed applications.

The main advantage offered by cloud computing is its ability to be easily extended and incorporated into other applications, increasing productivity when creating new applications. Because of this, the big tech companies and social networks (e.g., Facebook, Apple, Google, Twitter etc.) have their services available in this model of computing. Just to cite one example, a cloud application used extensively is Google Maps. Today there are countless applications that extend their functionality offering complementary services, such as geolocation applications that control the route, pace and calories consumed by an athlete over a physical activity, available in most current smartphones. It is precisely this capacity of expansion and productivity that we are exploring in

this project. We are creating the basic editing services, management and manipulation of concept maps that will be available to anyone in the world through our platform of services.

We call the proposed service oriented platform *CMPaaS* (Concept Maps Platform as a Service). One of the fundamental features of the architecture being used in this project, known as SOA (Service Oriented Architecture), is its ability to promote integration. This means that new services that extend the functionality of the services offered by *CMPaaS* can be developed and made available by anyone, anywhere in the world. The promotion of this scenario of collaboration and integration between the academic community and enterprises is one of the central goals of this project.

We also want to point out that the platform services are being implemented as Web Services. Since this is a mechanism of internal operation, applications providing a user interface need to be utilized. Thus, the *CMPaaS* is associated with a portal named "Knowledge Portal" that serves as the interface for the use of the tools offered. In Figure 1 (a) one can see how the portal tools interact with the services provided by the platform, while Figure 1 (b) shows how the community can integrate its services with the internal services of *CMPaaS*.

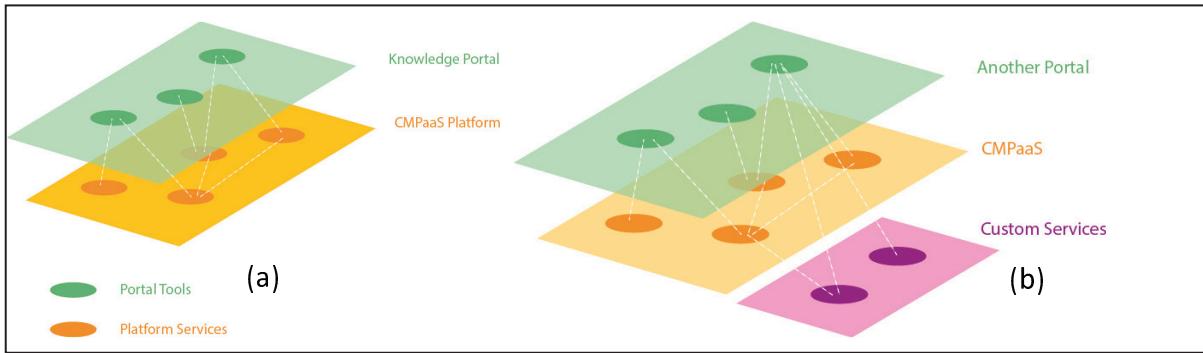


Figure 1: (a) View of integration of the knowledge portal with the platform. (b) View of integration of an external portal and services with *CMPaaS*.

As can be seen, the tools available on the portal are utilizing services of the platform. It is noteworthy that a single tool can be utilizing more than one service simultaneously. As an example, take the map-editing tool. While a user edits a map, the editing service is working to provide the visual characteristics of the map to the editor. At the same time, the authentication service is active to inform which user is making changes to the map. And even more, the service versioning needs to validate each version of the map. We therefore have a unique tool utilizing three platform services.

A single service of the platform can also be utilized by various tools of the portal. As an example, we can mention the maps listing service. It can be used by the concept maps query tool as well as by the maps merge tool. Both scenarios demonstrate how this architecture allows for the integration of the tools. Following we will present more details of the internal architecture of *CMPaaS*. We will also describe its main components, services and tools as well as the current stages of development of the portal.

3.1 General Architecture of *CMPaaS*

Internally, the platform consists of four layers (Figure 2): (i) external services, (ii) business processes, (iii) services of the internal applications, and (iv) internal components. The External Services layer is responsible for providing the services that will be utilized by the community (e.g., government agencies, private entities and ordinary people). In other words, the External Services layer is responsible for performing the interaction between the external world and the internal world of the platform. The Business Processes layer is responsible for managing business rules of the platform. This layer serves for the implementation of the processes that manage all services provided by the platform. The Internal Service Application layer is responsible for managing the services used by the business processes. This layer provides for the services of the internal components for the processes of the platform. Finally, the Internal Components layer is responsible for managing the components that provide all the services of the platform. For example, in this layer are the components for managing the users and concept maps.

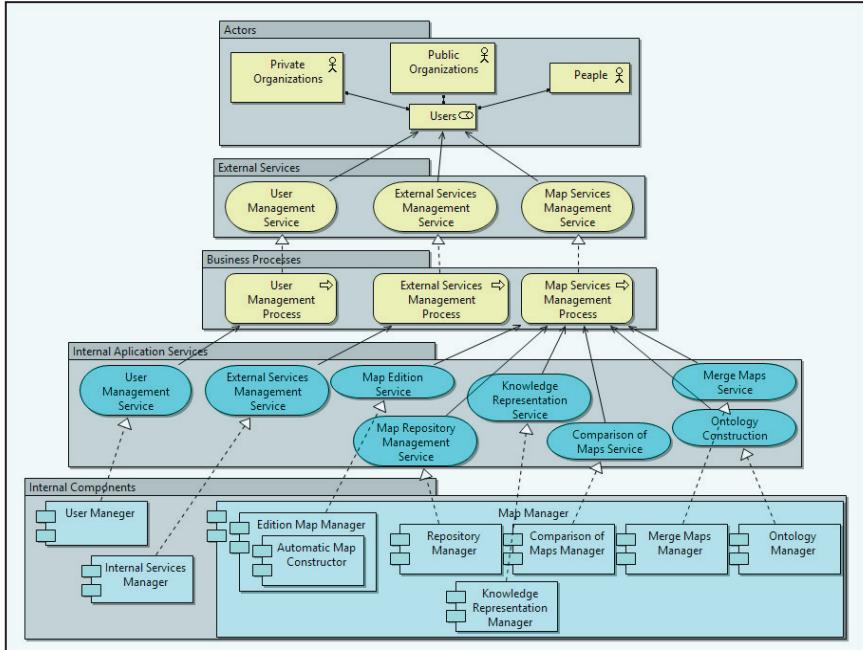


Figure 2: Functional view of the architecture of the platform *CMPaaS*.

Following, Figure 3 shows a simplified view of the major components of the overall architecture of *CMPaaS* as well as its interactions.

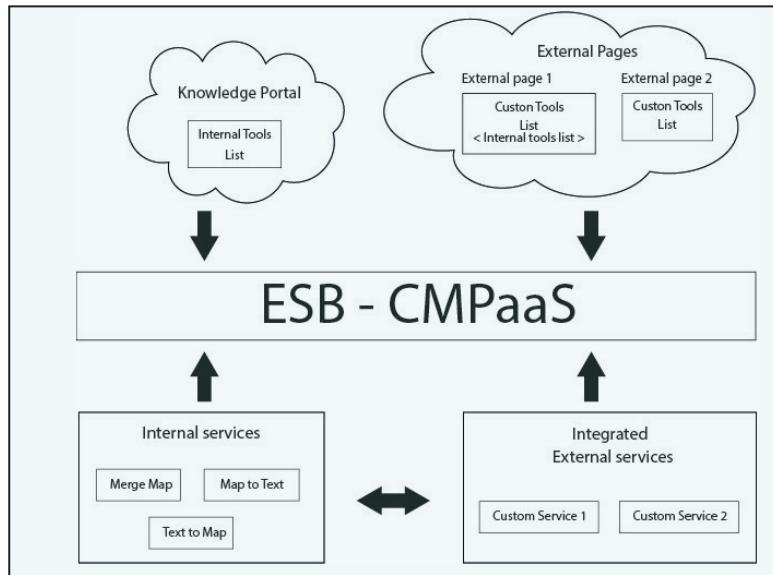


Figure 3. Conceptual architecture of *CMPaaS*.

As we can see there are three components in the architecture of *CMPaaS* which will be described in the following subsections.

3.1.1 ESB (Enterprise Service Bus)

ESB is the component of the architecture that provides the basis of services for more complex architectures via event drivers and patterns based on messages. It is responsible for providing an abstraction of layers in the implementation of the messaging system which allows the integration of architecture to exploit the value of messages, without the need to write complex code. This is the central component of the project because it aims to remove the coupling between services and transport.

3.1.2 Platform Services

Services are the features that will be provided by the platform for the presentation layer (the portal). These features include: user authentication, persistence and management of concept maps, analysis and manipulation services of concept maps, among others. It is worth noting that not all the services are of our own, since the general community can use the basic services provided by us and create new services that may be provided by them, or submitted to *CMPaaS* to become an integral part of our services. We call the services provided directly by *CMPaaS* internal services. The ones provided by third parties we call external services. It is noteworthy that all the services can communicate, integrating themselves with other services through the ESB.

Internal services are necessary functionalities for the management of users and their concept maps. These services form the kernel of the platform, i.e. they comprise the basic infrastructure of the platform. The external services are added to the platform services by the community, whether academic or not. Through these new external services the platform becomes extensible and dynamic. It is important to note that the processing of external services is initially not the responsibility of the platform. Such services shall be processed outside of the platform infrastructure. The platform only has the responsibility of managing the use of the services it offers.

Furthermore, with respect to the internal services, they are classified as: 1) platform management services and 2) basic services for constructing and manipulating concept maps. The internal platform management services are responsible for managing the users, the internal services (to add new users or new external services), and the services for map manipulation. The internal services for map manipulation are responsible for the basic functionalities for creating and manipulating the concept maps. Thus, within the context of this platform, the basic services resulting from academic projects and already defined and currently in development are:

- Concept maps edition service (S, 2005);
- Concept maps repository service (S, 2009);
- Concept maps comparing service (L, 2005);
- Concept maps merging service (G, 2014);
- Automatic concept maps generation (K, 2009, 2010);
- Service for generating ontologies from concept maps (P, 2010);
- Concept maps inference service (P, 2010);
- Service for automatic representation of Piaget's knowledge classes (C, 2013).

Some of these services already show results that will be presented in other papers. Others are functional prototypes being gradually incorporated into the *CMPaaS* platform.

3.1.3 External Services

Another goal of this platform is to provide services to the community, with concern of the visual presentation of its tools. This is done in two ways: (i) knowledge portal and (ii) external pages. Through the portal of knowledge the community can access, in a simple and fast way, the internal services of the platform. In other words, the portal is a means by which the community (teachers, students and other stakeholders) can use the services of the platform. The portal is the interface for all internal services of the platform.

Furthermore, the platform will be a means by which the developer community will utilize internal and external services as well as promote new services for the portal. It is worth emphasizing that an external service can utilize other external services, not just internal services. However, developers of external services will be responsible for providing an interface to use their services. They can do this through external pages or through applications for other devices.

In the development of the project we adopted techniques closely related to the concept of SOA, which by definition does not restrict developers to adopt languages or development technologies. Therefore, there are developers working on different languages and adopting different development techniques which will be integrated by using the services layer (Enterprise Service Bus). To ensure the availability of the platform services so as not to compromise other services that depend on them, versioning techniques that will enable version control and possible re-application of earlier versions services will be adopted.

3.2 *CMPaaS* today

Currently, *CMPaaS* project is in development. As its architecture is based on standard SOA, the development of the various services it comprises takes place in parallel by different teams composed of graduate students under

the supervision of researchers. Table 2 shows the services that are in the design phase of development, conclusion or testing.

It is worth mentioning that Table 2 presents only the services that are the result of work and research that are currently in progress. We envision the integration of several computational solutions already developed from previous research. Moreover, because of their extensible nature, we believe that many new services can be thought of, developed and incorporated into *CMPaaS* later.

Services of <i>CMPaaS</i>				
Service	Project	Developing	Conclusion	Tests
User authentication	X	X	X	X
Map persistence	X	X	X	X
Image generate	X	X	X	X
Transformation (Map to Persistence Model)	X	X	X	X
List of persisted maps	X	X	X	X
Maps merging	X	X	X	X
Proposition extraction	X	X	X	X
ESB integration	X	X		
Text to map service	X	X		
Intelligent engine for inference	X	X		
Query on maps	X	X		
Search for maps	X			
Auto layout generation	X			
Map validation	X			
Maps versioning	X			
Maps comparison	X			

Table 2: *CMPaaS* development status.

As the internal platform services require visual tools for exploitation by end users, the portal of knowledge and its tools are being developed in parallel to the development of *CMPaaS*. Table 3 presents the tools and activities that are already in development for the portal. Again, as the ongoing research advances and new services are added to the *CMPaaS*, the knowledge portal will be equipped with new tools that will be made available to the end-user community.

Tool and Activities of Knowledge Portal				
Tool / Activit	Project	Developing	Conclusion	Tests
Concept maps editor	X	X	X	X
Tool for merging maps	X	X	X	X
Maps manipulation page	X	X	X	
Text editor for automatic map generation	X	X		
Visual identity	X			
Portal page layout	X			

Table 3: Knowledge Portal development status.

4 Conclusions

Concept maps have interesting applications in various segments of society. However, many of their possible implementation approaches are avoided due to lack of tools apparatus to assist in the elicitation, organization, analysis and evaluation of the maps. We realize that many existing approaches involve the use of a heavy load of cognitive processing by the teacher or expert to analyze one or more maps generated by a group. We also see that the difficulty in developing specific solutions for automated processing and analysis of concept maps lies mostly in the fact that extensible platform services do not exist, through which developers can create their solutions without worrying about the basic services needed for their applications to be complete, such as the management of user accounts, manipulation and editing of concept maps etc.

This article aims to present the *CMPaaS*, a service-oriented platform whose goal is to provide the community in general, in addition to basic services, management and manipulation of concept maps, as well as more advanced services for analysis, statistical processing and evaluation of same. *CMPaaS* also allows these services to be extended and new services might be generated and integrated, significantly expanding the applications for the various approaches in the use of concept maps.

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COMPARING TWO FORMS OF CONCEPT MAP CRITIQUE ACTIVITIES TO SUPPORT KNOWLEDGE INTEGRATION IN BIOLOGY EDUCATION

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Abstract. Concept map activities often lack a subsequent revision step that facilitates knowledge integration. This study compares two kinds of concept map critique activities embedded in an evolution unit: Student dyads in one group compared their concept maps against an expert map while dyads in the other group conducted a peer-review. Analysis of the concept maps suggests that both treatment groups significantly improved their understanding of evolution. However, the two groups developed different criteria: The expert-map group focused mostly on concept-focused criteria like concept classification while the peer-review group used more link-focused criteria like link labels and missing connections. This paper suggests that both critique activities can be beneficial to making more coherent connections across different topics in biology.

Keywords: Science education, biology education, knowledge integration, learning by critiquing, Knowledge Integration Map

1 Introduction

Biology is often taught as isolated sub-fields each with its own terminology. As a result, many students leave school with a very fragmented knowledge of biology (Mintzes, Wandersee, & Novak, 1998, 2000; Wandersee, 1989) that does not allow them to understand complex scientific systems and make connections to their everyday lives. Particularly, the core domains of modern biology, genetics, cell biology and evolution, have been found to be conceptually difficult topics to teach and learn (Bahar, 1999; Tsui & Treagust, 2003). One main reason why they are difficult topics to learn is because they form a complex system with multiple interacting levels (Wilensky & Resnick, 1999). Comprehensive understanding of these complex systems requires simultaneous thinking in and connecting across several levels. Concept maps can help making connections within and across levels visually explicit.

Concept mapping has been shown to effectively support student learning and assess understanding of science concepts (Novak, 1996). However, many concept mapping activities used in classrooms miss a subsequent step that supports reflection and leads to a review process that helps refining students' work and integration of their ideas. A critique activity requires students to apply or develop criteria to reflect, revise their work, and self-monitor their learning progress (Chi, 2000). This study compares two different concept map critique activities: Students in one treatment group compared their own maps against an expert concept map while students in the other treatment group provided anonymous peer-review for other students' concept maps.

2 Theoretical Framework

Knowledge integration (KI) (Linn & Hsi, 2000; Linn, Eylon, & Davis, 2004) focuses on connections between ideas (represented as “concepts” in concept maps) and includes the processes of eliciting existing repertoires of ideas, adding new ideas to the repertoire, developing criteria to distinguish ideas, and sorting out various connections and ideas. In a concept map, ideas are represented by concepts, connecting arrows, the labels of arrows, and the placement of concepts in specific areas. Combining several ideas is interpreted as an increase in integrated knowledge. Concept maps as knowledge integration tools allow eliciting and critiquing concepts and relations between concepts (see table 1). The visual format of concept maps can foster critical distinctions between alternative concepts and relations, either individually or collaboratively in communities of learners. Concept maps allow for fast retrieval of information that allows for time-efficient comparisons.

Table 1: Concept mapping for knowledge integration

Knowledge Integration Process	Concept Mapping Activity
Eliciting existing ideas	Concept maps can be used as a pretest activity to elicit existing concepts.
Adding new ideas and connecting to existing ideas in repertoire	New concepts and relations can be added to existing concept maps. If applicable, students need to decide which concepts to add to the map. If several alternative relations between two concepts are possible, students have to decide which one to use in the map.
Distinguishing/ Critiquing ideas	Students apply or generate criteria to distinguish alternative concepts and relations (arrow directions and labels).
Sorting out ideas/ Refining/ Revising	Students sort out alternative concepts and relations based on different sources of evidence. Concepts can be rearranged into new groups and the concept map network structure might need revision the implemented changes.
Applying ideas	Concept maps can be used as resources to generate explanations of scientific phenomena.

This paper investigates ways to help students connecting different biology concepts to form a coherent view that allows understanding real life phenomena. This study combined learning from a dynamic computer-based inquiry activity with a scaffolded concept map construction and two different critique activities.

The specific research questions this study addresses are:

- 1) *How do expert and peer critique activities impact learning from a dynamic visualization? What connections among biology concepts do students make in each condition?*
- 2) *What are the differences between peer and expert concept map critique in regards to promoting knowledge integration?*

3 Methods

3.1 Curriculum Design

The curriculum unit, titled *Space Colony – Genetic diversity and survival* was deployed using the Web-based Inquiry Science Environment (WISE) (Linn, Davis, & Bell, 2004). The unit consisted of seven activities that emphasized connections between cell division, the underlying genetic processes, and overarching evolution principles. The unit included the computer-based visualization ‘EvolutionLab’ (Leif, 2005) that allowed students to run scaffolded experiments to investigate the connections between mutations and natural selection. Students worked collaboratively in pairs sharing one computer and spent five days (one hour per day) to complete the unit.

3.2 Novel form of concept map

This study took advantage of a novel form of concept map called Knowledge Integration Map (KIM) that incorporates research on knowledge integration and on concept mapping (Schwendimann, 2011, 2014). KIMs divide the drawing area into domain-specific areas to classify and distinguish different concepts. KIMs adapted for this study aim to support the generation and revision of concepts related to evolution by dividing the drawing area into the biology-specific areas ‘DNA’ (micro), ‘cell’ (meso), and ‘organism/population’ (macro) (see figure 2). Genetic concepts were expected to be placed in the ‘DNA’ area while concepts about the phenotype and natural selection would be placed in the ‘organism/population’ area. The ‘cell’ area aimed to serve as a meso-level bridge between the genetic (micro) and the organism/population (macro) areas. Learners received a list of six concepts and were instructed to first classify the concepts by placing them into the corresponding areas and then to construct connections (with labeled mono-directional arrows) within and across areas.

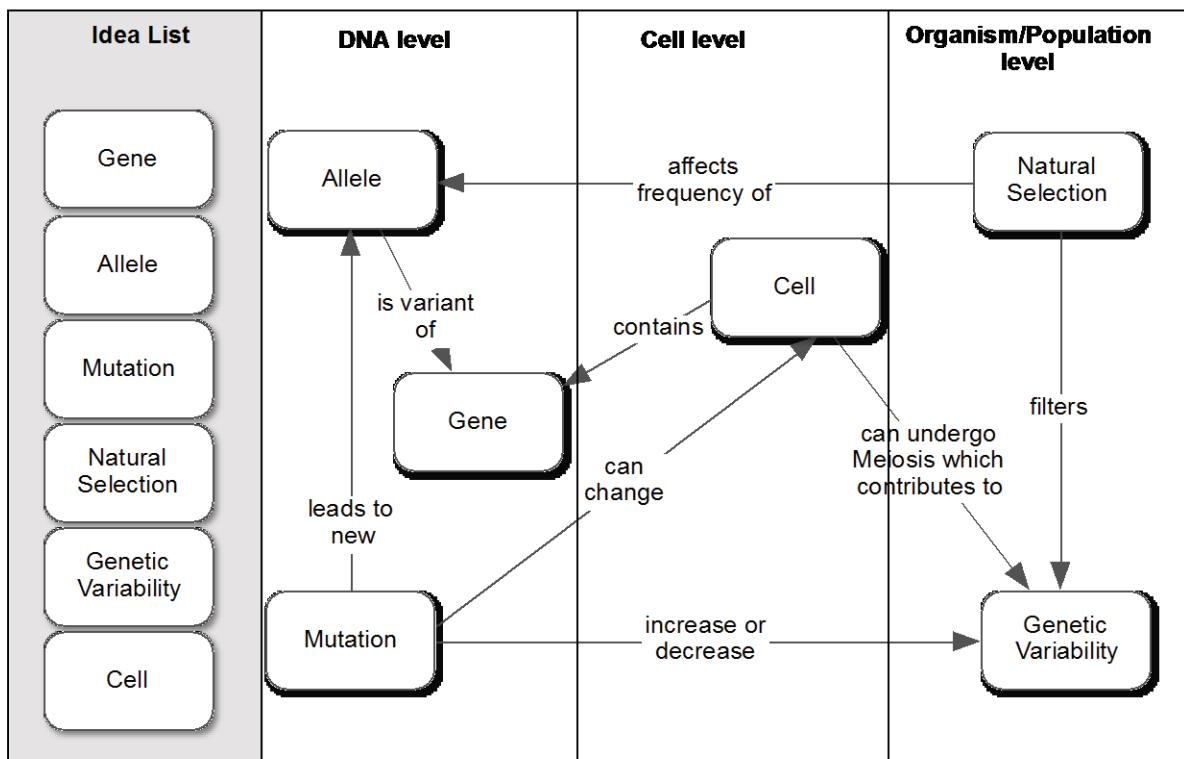


Figure 2: Knowledge Integration Map (KIM)

3.3 Data Sources

Pre/posttests measured students' improvements in connecting genetics, cell biology, and evolution. The pre/posttests consisted of nine explanation items that required students to apply the principles of the genetic basis of evolution to novel contexts. Pre/posttests were scored according to a five-scale knowledge integration rubric (Linn, Lee, Tinker, Husic, & Chiu, 2006).

Concept maps: All students received initial training in the method of concept mapping. A paper and pencil KIM activity was administered after completing the 'EvolutionLab' activity. Student dyads created a KIM out of six given concepts: Gene, allele, mutation, cell, natural selection, and genetic diversity. Students were instructed to classify the concepts by placing each in one of three areas (DNA level, cell level, organism/population level) before connecting the concepts with labeled mono-directional arrows (see figure 3).

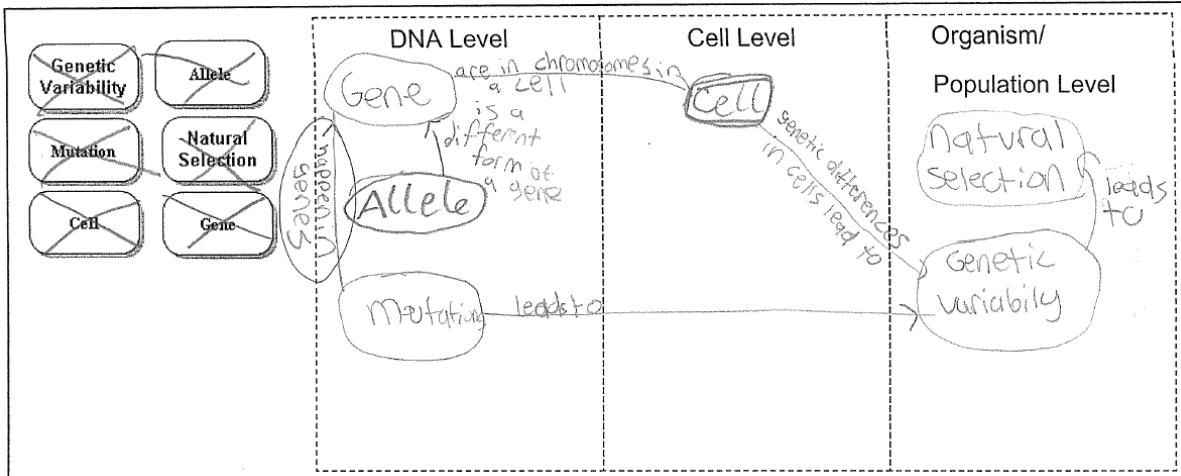


Figure 3: KIM student example (from the peer map group)

KIM propositions were coded using a knowledge integration rubric for concept maps (table 2) (Schwendimann, 2008) on a scale from 0 to 5, a higher score indicating a more complex connection. The rubric

distinguished between link label and link arrow. Additionally, the placement of concepts in one of the three areas (DNA, cell, organism/population) and cross-links (links between areas) were evaluated.

Table 2: Concept map scoring rubric

KI Score	Link label quality	Link Arrow	Example
0	None (missing connection)	None	
1	Wrong label	Wrong arrow direction	<i>Genetic variability includes mutation</i>
2	Inconsistent/vague: a) Only line b) Correct label c) Incorrect label	a) Only line b) Wrong arrow direction c) Correct arrow direction	<i>a) Mutation -- genetic variability b) Genetic variability – contributes to > mutation c) Mutation – includes > genetic variability</i>
3	Correct arrow (but no label)	Correct arrow direction	<i>Mutation -> genetic variability</i>
4	Partially correct, but weak	Correct arrow direction	<i>Mutation – increases ->genetic variability</i>
5	Fully correct, strong	Correct arrow direction	<i>Mutation – causes random changes in the genetic material which in turn increases > genetic variability</i>

Critique activity: A worksheet instructed student dyads to compare their KIM to a reference map – either an expert-generated map or a map constructed by a peer dyad. Students had to develop their own criteria, select the most saliently different element in the map, and then explain their choice. The authors were asked to respond to the critique by describing their intended response (for example revising the KIM accordingly or ignore the critique). A rubric for the different kinds of concept map critique criteria has been developed (table 3). All rubrics showed a high inter-rater reliability.

Table 3: Rubric for different concept map critique criteria

Kind of critique	Example
Missing	
Off-Topic	<i>I am tired</i>
General	<i>Make more links between your concepts.</i>
Critique of concept placement	<i>'Mutation' should be in DNA-Level</i>
Critique of missing concept	<i>You forgot to add 'mutation'.</i>
Critique of arrow-direction	<i>Your arrow should go in the other direction</i>
Critique of missing link	<i>You missed to connect 'mutation + allele'.</i>
Critique of missing link-label	<i>You should add a label for the link 'mutation + allele'</i>
Critique of existing link-label	<i>Connection between 'allele' and 'mutation' should be 'leads to' and not 'includes'.</i>

3.4 Participants

The WISE unit ‘Space Colony – Genetic diversity and survival’ was implemented by two teachers each with two classes in one US public high school. One class of each teacher got randomly selected for one treatment (expert map comparison or peer-review). All students were in 9th and 10th grade and came from a variety of ethnic and economic backgrounds. Only students who completed the concept mapping activity and the pre/posttest were included in this study (n=81). T-test analysis showed that the prior knowledge as measured in the pretest did not significantly differ between the classes of the two teachers [$t(80) = -0.67$, $p>0.05$ (two-tailed)].

4 Results and Discussion

Research question #1: *How do expert and peer critique activities impact learning from a dynamic visualization? What connections among biology concept do students make in each condition?*

A paired t test indicated that students in both treatment groups gained significantly in their understanding of evolution ideas from pre- to posttest. [Paired $t(80) = 4.15$, $p<0.0001$ (two-tailed)]. Effect size (Cohen’s d)=0.52 (SD pretest=2.78, SD posttest=3.17)] (see figure 4)

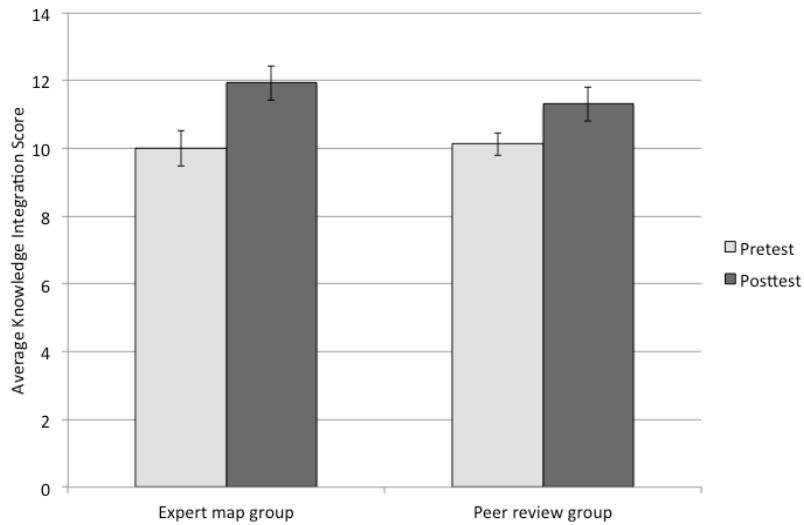


Figure 4: Pretest-posttest gains (by group)

No significant difference of the posttest performance of the two critique groups was found [$p>0.05$ (two-tailed). $t(79) = 1.0030$, $p>0.05$ (two-tailed)]. This could be explained by the short duration of the treatment and the nature of the critique activity that led to more reflection in both treatment groups.

Analysis of the frequency of propositions after the revision indicates that connections between concepts that were learned within the same context were most frequent, e.g. ‘genetic variability + natural selection’ (evolution concepts) (see figure 5 box on the left). Connections across levels or topics that needed to be newly generated by the students were found less frequently, e.g. ‘genetic variability + allele’ (see fig 5 middle and right box). Connections across levels can be interpreted as newly created connections as they were not included in the textbook. Findings suggest that the WISE unit ‘Space colony’ effectively helped students in both treatment groups making novel connections across levels and biological topics. The peer-review group created more across-level connections, for example ‘genetic variability + gene’, than the expert map group. This could have been encouraged by the link-focused feedback by peer-review dyads (see research question #2).

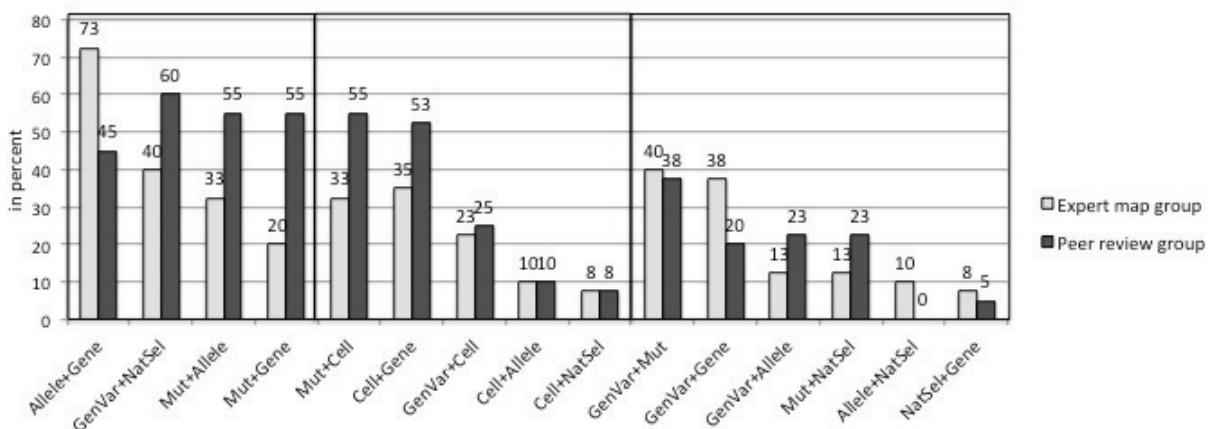


Figure 5: Frequencies of propositions connecting across contexts (left box= within same context; middle box = across one context; right box = across two contexts) (in percent)

Research question #2: *What are the differences between peer and expert concept map critique in regards to promoting knowledge integration?*

Both treatment groups significantly improved their concept maps after the critique activity [paired $t(80) = 4.13$, $p<0.0001$ (two-tailed)]. Regression analysis showed that an improvement in the concept maps after the revision is positively associated with an estimated increase in the mean posttest score of 2.5; $p<0.001$.

Students generated a broad variety of criteria to review different elements of KIMs (see figure 6).

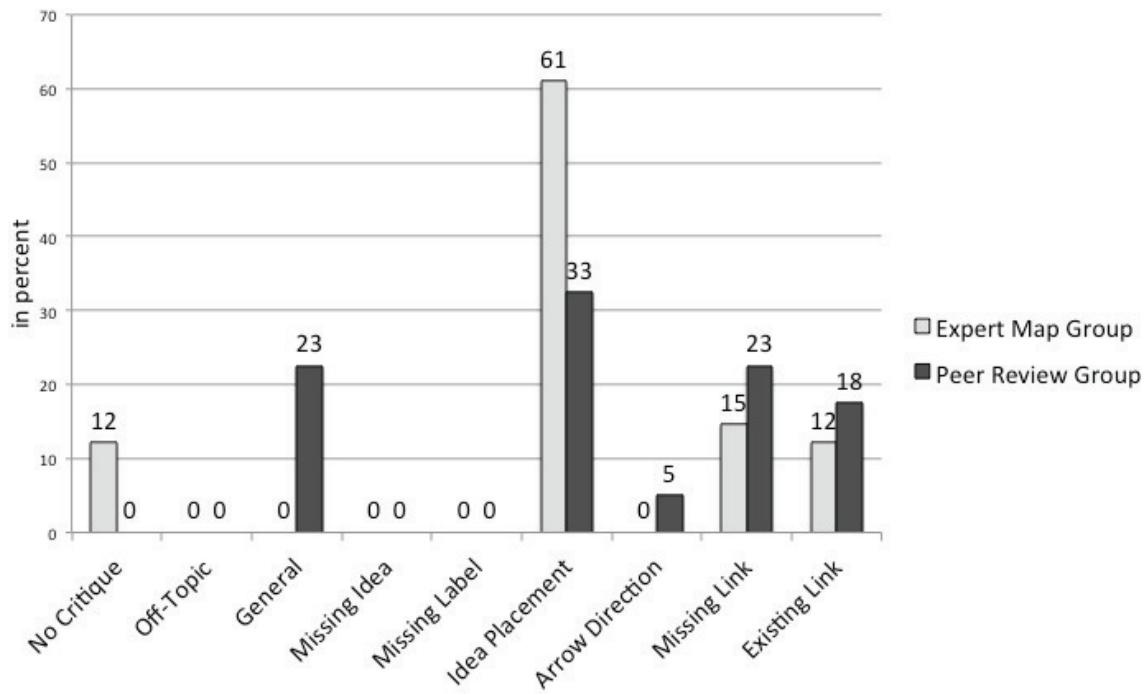


Figure 6: Criteria (by group)

KIM generation: Student dyads in both conditions collaboratively generated their own KIMs from a given list of ideas. The KIM generation activity aimed to elicit existing alternative ideas through idea placement and connections. In their initial KIMs, students in both conditions showed a similar array of alternative ideas. Generating KIMs can elicit alternative ideas as well as missing connections.

KIM critique: While students in both conditions generated similar KIMs, analysis of dyad-generated criteria suggests that students in the expert and peer conditions differed significantly in the ways how they critiqued and revised KIMs. Students in the expert map group used mostly the criteria ‘idea placement’ (61%), ‘missing link’ (15%), and ‘change existing link label’ (12%). Students in the peer map group showed a different distribution: only 33% critiqued idea placements, but 23% critiqued missing links, 18% existing link labels, and 5% link directions. No student dyad critiqued a missing idea or a missing label. This might be explained by the explicit instructions to use all given ideas and label all connections. All students in the peer map group provided some form of critique while 12% of dyads in the expert map group did not provide critique (of their own work). This could suggest that critiquing peers’ work is more interesting and engaging than critiquing one’s own work.

For further analysis, student-generated criteria were grouped into the three categories ‘idea-focused criteria’, ‘link-focused criteria’, and ‘non-relevant criteria’ (see table 4).

Table 4: Categories of student-generated criteria

Criteria grouping	Category
No Critique + Off Topic + General	Non-relevant criteria include missing, off-topic, and general comments.
Idea Placement + Missing Idea	Idea-focused criteria allow for a quick visual comparison between KIMs without necessary conceptual reflection (for example “Is the idea placed in the same area as in the expert map?”; “Is an idea from the given list missing?”)
Arrow Direction + Missing Link + Existing Label	Link-focused criteria provide conceptual feedback by identifying an important missing connection, pointing out that an arrow direction should be reversed, or suggesting the revision of an existing label.

Idea-focused criteria evaluate the presence or placement of ideas while *link-focused criteria* identify missing links, the direction of a link, or the link label (see figure 7). Student dyads in the expert and peer groups differed significantly in the prominence of criteria for their KIM critique. Z-scores were computed for raw scores in the critique data set. The differences in proportions of the criteria categories between conditions are statistically significant: Idea-focused critique ($z=2.97$, $p=0.001$) and link-focused critique ($z=1.68$, $p=0.046$).

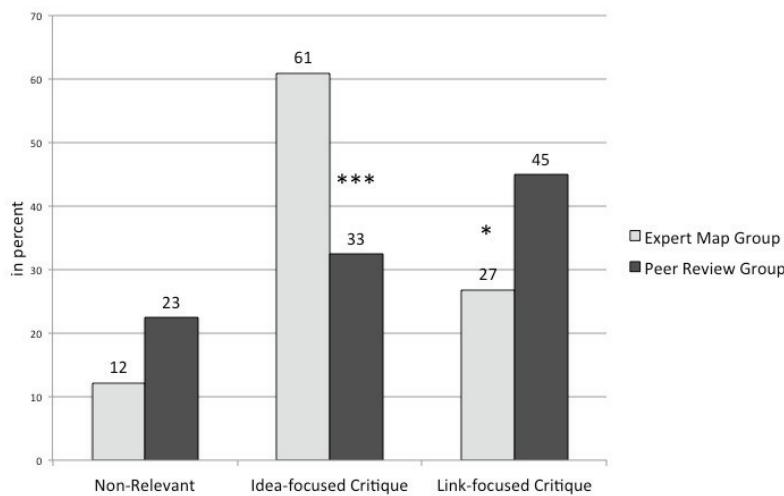


Figure 7: KIM criteria categories (*= $p<0.05$; **= $p<0.01$; ***= $p<0.001$)

In summary, both critique groups did significantly improve their concept maps after their revision and gained from pre- to posttest. As both critique activities led to reflection and revision, the two treatment groups did not significantly differ in their posttest performance. However, the groups differed from each other in the different kinds of criteria used to review their maps. This study suggests different mechanisms and criteria involved in the two critique activities.

- Students in the expert map condition generated more *idea-focused criteria* (61%) that allowed for quick comparisons with the expert map. Aligned with their criteria, most students in the expert-map group decided to revise their idea placement. For example, a dyad in the expert group stated, “We think that the location of ‘genetic variability’ is most different”. They used an idea-focused criterion to compare their map to the expert-generated map and identified the most saliently different element. Consequently, the authors then suggested moving the idea to a different area. Critiquing your own work can be more difficult than evaluating other people’s work. Findings suggest that providing students with a normative benchmark helped modeling expert understanding and distinguishing idea-focused issues for revision.
- The peer-review activity engaged students to develop and use more *link-focused criteria* (45%), like missing propositions, link labels, and causal directions. Comparing their own ideas against those of their peers helped students to value their own ideas while developing criteria to critically review them. One explanation for this observation might be students’ interest in seeing work created by their peers (although anonymous) and being in an equal position to critique each other’s work. Peer-generated KIMs might be easier to compare to one’s own than to an expert generated KIM because of the use of familiar language and building on similar prior knowledge. One initial concern for the peer review activity was that students might receive peer-generated work of varying quality and provide feedback that might reinforce non-normative ideas. Results suggest that some peer feedback consisted of non-normative ideas. However, students successfully distinguished alternative ideas, rightfully discarded non-normative suggestions, and expressed confidence in their own ideas.

5 Implications

Both forms of critique can lead to reflection, help students build criteria for self-monitoring their learning progress, and support knowledge integration processes. A combination of the two forms of critique activities could be implemented in a future iteration of this study. Students might also be provided with a critique rubric that allows them to systematically review different elements of their concept maps.

6 Acknowledgements

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CONCEPT MAP TO SOLVE CLINICAL HEALTH CASES: HOW WE DO IT

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Abstract. We have used school-based case studies in the training of health professionals for a more enjoyable learning and to assemble a variety of content areas to produce knowledge, to foster decision making skills, and attitudes in agreement with the relevant listing, critical and ethical standards required for a health professional. Objective: Our main purpose in this study was to describe the use of Concept Maps (CM) as a strategy for undergraduate nursing students to solve clinical cases, as well as evaluate the performance and opinion of students about the use of CM as a tool to solve clinical cases. Method: This is a descriptive study of educational intervention with quantitative and qualitative analysis. The study was performed with undergraduate nursing students from the third period of nursing practice discipline of adult and elderly health at a public university in São Paulo. Results: Several groups have showed us that the strategy has helped them to learn, to make associations between the multidisciplinary content, to understand the clinical conditions and to develop clinical thinking. Groups, CM1 and CM2, had $p=0.0008$ and $p=0.0222$, respectively. Conclusion: The strategy has helped students to develop critical thinking, and there was a noticeable improvement in their ability to develop CM.

Keywords: Concept Mapping; Theory Development; Research Development; Critical Thinking

1 Introduction

Recently more discussions and actions have occurred related to educational technology in the field of health. The search for different strategies to teach is justified because it may give rise to dynamic and useful teaching situations to develop professionals with critical and reflexive thinking, clinical decision-making, and evidence-based practice skills (Leonello & Oliveira, 2008; Chambers, 2010).

Among the innovative teaching strategies, the Concept Maps (CM) has highlighted. Using student's backgrounds, educators can evaluate how students organize concepts. This tool also helps to identify the network relationship with multilinear characteristics, i.e., it is not restricted to Cartesian thinking (Cañas & Novak, 2008; Novak & Gowin, 2008). Based on this knowledge, we implemented Concept Maps strategy to solve clinical cases in the discipline of nursing practice of adult and elderly health at Universidade Federal de São Paulo - UNIFESP, mainly because this discipline involves theoretical lectures and a period of hospital practice training (De Domenico et al., 2008).

The case study method is widely used in health sciences teaching by enabling the development of reasoning and clinical judgment (Garvin, 2003; JE Thistlethwaite et al., 2012). The process of diagnosis, to identify patient illness and provide appropriate treatments, is complex, it demands knowledge from different disciplines so the health professional can explain and predict what is happening and the consequences of different treatments. The clinical cases used were based upon real case scenarios involving medical diagnosis, signs and symptoms, results and tests, proposed treatments, psychological, social and cultural data of patients with cancer. We expected that students could find the relationship between concepts, find out relevant data, proper diagnosis, and also to make decisions to come up with different care interventions with efficiency and safety. These steps, closely related to clinical thinking, would become indexes to create a CM model, and to make the criteria for correction.

We have applied the strategy for three years. In the first year, 2008, we assessed the student's opinion based on the study done by De Domenico, et al (2008) about the exercise to solve a clinical case, the advantages and disadvantages to include CM in the discipline, and what kind of positive and negative issues a CM construction could bring. Using that method the CM promoted curiosity among students across all the academic world, and a willingness to investigate and combine relevant data. In addition, it stimulated them to find out more about scientific findings that could help them to innovate standard interventions (De Domenico et al, 2009).

Most of the students enjoyed creating the CM; however, the majority reported that it was difficult and required a great deal of work. After assessment, we realized that would be important to develop clinical thinking in undergraduate nursing students to continue to use and improve the CM strategy.

In the second and third years, 2009 and 2010, we created two CMs to get two different assessments. The first assessment after the theoretical class and other after hospital practice training. We detached the CM strategy into after and before the hospital practice, so we can assess the teaching contributions in to improve students' clinical thinking. this study was primarily driven by our desire to know what is the scope of this method and after that, to gather data to enhance the strategy application.

This experience lead us to the main question of this study: what is undergraduate nursing students' self-perception on their performance during class after hospital practice training with CM? What was student's performance in solving clinical cases through CM? **Objectives:** Our main purpose in this study was to describe the use of Concept Maps (CM) as a strategy for undergraduate nursing students to solve clinical cases, as well as evaluate the performance and opinion of students about the use of CM as a tool to solve clinical cases.

2 Method

2.1 Design

In order to analyze meaning expression, students perceptions and suggestions about their own performance, we proceed with a descriptive study of an educational intervention with a qualitative approach. Also, a quantitative analysis of grades was obtained from the two concepts mapping constructed by participants.

2.2 Participants

Nursing undergraduates attending the third period in 2009 and 2010 nursing practice of adult and elderly health classes at Escola Paulista de Enfermagem (School of Nursing) da Universidade Federal de São Paulo-UNIFESP, São Paulo, São Paulo, Brasil.

2.3 Gathering data

We have grouped students accordingly to age and previous experience in using computational technology. After the second CM assessment, the 2009's group, with ten students, gave us the qualitative sample. In the same year we created the Focus Group (FG) to apply a qualitative data collection technique connecting researcher and subjects. Such an approach allowed integration in the group and fomented discussion among participants. This technique consist of the formation of a group involved with a problem to be addressed by the participants that are grouped accordingly to eligibility criteria related to the study design, which could vary from 4 to 12 participants (Dilorio et al, 1994).

We included in this study those who concluded the CM1 and the CM2 construction. Firstly, we asked the participants to describe the experience of creating the CM1 and CM2, then their answers were recorded and transcribed. Qualitative data of students from 2009 and 2010 were obtained after the conclusion of the following steps.

2.4 Data analysis

We used the content analysis created by Bardin (2012) to analyze the data from the FG. The registering units and codes outcomes were gathered into categories, which were analyzed considering its references of effective learning and CM construction.

For quantitative analysis we divided the score into quartiles (0 to 100%) and measured it by means and standard deviation. We carried out with Shapiro-Wilk because the sample was less than 2.000. To inferential analysis using the analysis of variance (ANOVA) both groups from 2009 and 2010 presented similarity among scores of CM1 and CM2. The confidence level considered was 95%.

3 Results

3.1 Description of the educational plan

Firstly, for each year of the strategy application we created three phases: planning, action, and assessment.

- a) Planning: a clinical case was elaborated with a few data in the CM1, such as: patient identification (gender, age, job position, housing, family constitution, religion/beliefs), companion identification, diagnostic, exams (laboratorial and imaging), treatments (clinical and surgical), emotional status. New data about previous problems evolutions were presented using the same clinical case in the CM2.

Figure 1 describes correction criteria for the CM1 and CM2. Scores are defined accordingly to the number of data acquired from clinical case, i.e., if there were 10 relevant data, the student needed to describe all of them in the CM to obtain these 2 points, or describe 5 to obtain 1.0 point.

Criteria for Correction of Concept Maps to Solve Clinical Case	Score
Selection of relevant data of the clinical case	High score: 2.0 score; 75%: 1.5 score; 50%: 1.0 score; 25%: 0.5 score; low: zero
Identification of Functional Change in Health Standards	High score: 2.0 score; 75%: 1.5 score; 50%: 1.0 score; 25%: 0.5 score; low: zero
Identification of Actual and Risk Nursing Diagnosis which defines characteristics and related facts (associations between biological concepts of clinical case in psychosocial and spiritual content).	High score: 2.0 score; 75%: 1.5 score; 50%: 1.0 score; 25%: 0.5 score; low: zero
Proposition of Focused Investigation from analysis of insufficient data: to form question	High score: 1.0 score; 75%: 0.75 score; 50%: 0.5 score; low: zero
Description of Nursing Outcomes: considering intervention planning and nursing evolution	High score: 1.0 score; 75%: 0.75 score; 50%: 0.5 score; low: zero
Proposition of Nursing Interventions: the action taken must be related to nursing diagnosis. The action should be based on scientific evidence, and reference citation provided.	High score: 2.0 score; 75%: 1.25 score; 50%: 1.0 score; 25%: 0.5 score; low: zero
Total	10.0 (ten)

Figure 1: Criteria for correction of Concept Maps to solve clinical case.

- b) Action: In the beginning of the theoretical module we taught the students how to proceed with the CM1 and set up a deadline, normally after 45 days, at the end of the module. As shown in Figure 2, we also provided a Nursing Process (NP) based model to help them to solve clinical cases using CM.

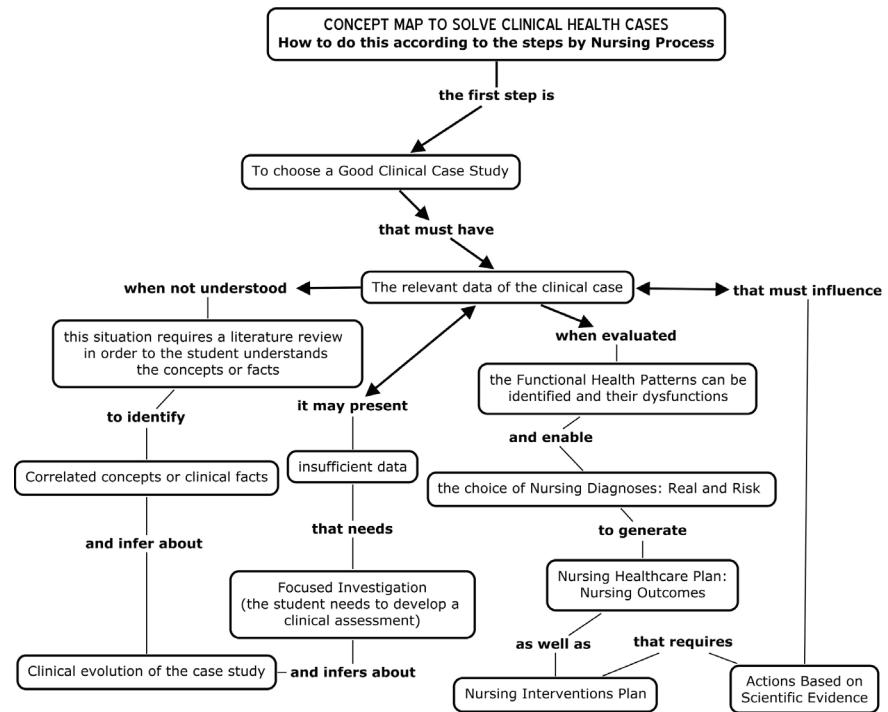


Figure 2: Model to solve a clinical health case using the MC, according to the Nursing Process.

Students were encouraged to ask questions to erase any doubts during the practice. Most doubts were related to the resolution of the clinical case and about CmapTools software, a program required for the task. In 2009, we gave printed handouts about the software to the students, which evolved into stored USB files in 2010. After correction of the CM1 a score of 0 to 10 was given and the students were instructed to proceed with CM2 considering the same clinical case and the CM1 corrections. They presented the results in the last week of hospital practice training.

- c) Assessment: Figure 1 shows the criteria used to correct both CM. In addition, we added comment to help students to think about their choices and how to conduct the case in CM2. We used the tool “comment” in CmapTools software to give suggestions and to clarify mistakes. We also told students their individual CM score and final grade score.

3.2 Performance results and the students' opinion

We gathered data from the FG in July 2009 after the students take part in a informed consent, which lasted 70 minutes. All participants were women aged 19 to 22 years who claimed to have had experience with computer for schooling and entertainment purpose, but did not know the CM strategy.

We asked students about the experience of creating CMs (1 and 2) and their testimonials gave us analytical categories showing enhancement and development of clinical thinking. It also showed us some challenges the participants faced during practice. Students were tagged as “S” (S1, S2...).

We obtained 2 categories from the FG discussions: CM enabled multidisciplinary studies and relationship between content, but it required hard work (Figure 3) and CM to support clinical conditions understanding and to develop clinical thinking.

Testimonial	Inferential Analysis
<p>“(...) to create a CM impelled me to seek more knowledge in some subjects, correlated subjects.” (S3, 2009)</p> <p>“I thought this exercise was good mainly because it enabled me to link knowledge, because (...) during undergraduate (...) contents are separated throughout the years (...). The Concept Maps puts everything together.” (S7, 2009)</p> <p>“(...) in the beginning it was not easy (...), specially nursing, which required to build a diagnosis and interventions.” (S4, 2009)</p>	<ul style="list-style-type: none"> - Motivate studying - Satisfaction because it correlated multidisciplinary data - Hard to do, mainly clinical decision-making.

Figure 3: Category 1: CM enabled the study and link of multidisciplinary contents, but it required hard work

Regarding the period in hospital settings, which integrates the discipline of nursing practice of adult and elderly health, students reported enlarged their sense and meaning of clinical thinking, besides the satisfaction with the final result of the CM2 (Figure 4).

Testimonial	Inferential Analysis
<p><i>"The CM helped me during my internship (...) Many things I studied during practice I have already learned in the CM1, particularly on physiology and diagnostic test."</i> (S5, 2009)</p> <p><i>"The internship helped me to understand better the second map, because you do not learn only by theoretical lectures, but acting in real situations. This experience helps you to think critically and it even improves your ability to make nursing diagnosis."</i> (S4, 2009)</p>	<ul style="list-style-type: none"> -CM1 solving helped to understand pathophysiological aspects of the clinic -Practice experience helped in CM2 construction -There was a development in critical analysis and clinical thinking in CM2.

Figure 4: Category 2: CM as a facilitator to clinical conditions comprehension and to develop clinical thinking.

We organized the students from both years to gather solid data to assess student's performance. We have a total of 97 students with age ranging from 19 to 23. All participants had declared to have computer literacy. Participants who had completed both Concept Maps were included. Thus, grades of 56 students from 2009 group and 41 students from the 2010 group were obtained.

Table 1 shows normality tests and the analysis of grades from the 2009 group with variable quartiles, mean and standard deviation.

Table 1: Distribution of grades of the CM1 and the CM2 of 2009 group for quartiles and central tendency

Variables	n	0%	25%	50%	75%	100%	Mean (DP)	S-W
Grades of CM1	56	0	3.5	4.75	6.5	10	5.0 (2.3)	0.2863*
Grades of CM2	56	3	5.6	7.75	8.4	10	7.2 (1.7)	0.0048
Differences of grades in CM1 and CM2	56	0	0	1.6	4	7.5	2.1 (2.2)	<0.0001
Mean	56	2.25	5	6	7.5	10	6.1 (1.7)	0.6043*

S-W: Shapiro-Wilk test for normality * Sample came from normal distribution

Table 2 presents results from the 2010 group.

Table 2: Distribution of grades of the CM1 and the CM2 of 2010 group for quartiles and central tendency

Variables	n	0%	25%	50%	75%	100%	Mean (DP)	S-W
Grades of CM1	41	3	4	5	6	8	5.1 (1.2)	0.1399*
Grades of CM2	41	4.5	6.75	7	8.75	10	7.3 (1.5)	0.0131
Differences of grades in CM1 and CM2	41	0.5	1	2	3.5	5.5	2.2 (1.5)	0.0014
Mean	41	4	6	6.25	7	8.5	6.2 (1.1)	0.0082

S-W: Shapiro-Wilk test for normality * Sample came from normal distribution

Variables of grades in CM1 and the mean in the 2009 group had normal distribution. In the 2010 group only the variables of grades in CM1 had normal distribution, for this reason, we used the Wilcoxon test/Kruskal-Wallis test to compare samples. We used ANOVA for numerical variables analysis. Data from the 2009 group had significant statistical differences ($F=12.5121$, $p=0.0008$) among grades of the CM1 and the CM2, being grades higher in the CM2. The same happened in the 2010 group ($F=5.6702$, $p=0.0222$) in the CM2.

The box-plot in figure 5 presents the comparative analysis of groups from the 2009 and the 2010 groups about the students' performance in the CM1 and the CM2 construction.

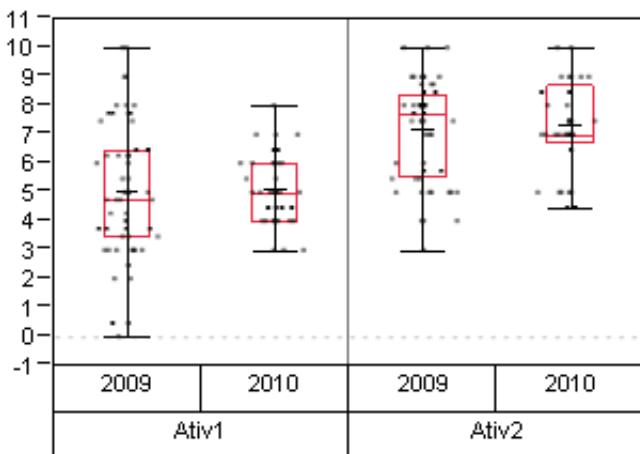


Figure 5: Box-Plot showing variability of grades of the CM1 and the CM2 in 2009 and 2010.

4 Discussion

Discussion in the FG about the experience of creating Concept maps shows us that CM strategy is a good initiative which helps students to connect multidisciplinary content, as well as understand clinical condition and develop clinical thinking. Our results were similar to other studies that used CM in health sciences (Kathol et al, 1988; Daley, 2004).

Despite the opportunities mentioned above, there were some complaints due to the complexity of CM construction. Defining nursing diagnosis over identification of relevant clinical data with posterior analysis to choose suitable intervention gave rise to doubts and obstacles to build the CM. Such problems were mainly seen in the first CM, because students at that time did not have experience in hospital settings. Students clinical skills should be developed due to nursing learning process, continuous scientific knowledge development focused on quality stages and the ability to turn theoretical knowledge into practice (Daley et al, 1999; Ironside, 2003).

Hence, the difficulty to develop consecutive stages of clinical decision-making (nursing process) without previous hospital experience may be considered a result of few attributions of information meanings in a clinical case. The criteria defined for correction of CM pointed out the relationship between critical thinking, clinical competence from a descriptive knowledge, quality of inferences, investigations focused on specific problems, abstractions and generalizations that require the student to consolidate formal knowledge with clinical experience, which depends on cognitive, psychomotor, and professional affective knowledge (De Domenico et al, 2009). Students get in touch with hospital environment only during the third and fourth years of nursing college at our institution, therefore, the difficulty faced by students during CM construction is justified because they do not have practice with real life situations.

However, other testimonials revealed that the second map was easier after the practice experience at the hospital units. An improvement in performance in both groups from 2009 and 2010 was observed regarding the development of stages of clinical decision-making, specially the ability to make clinical choices. The mean scores also showed a positive result. CM1 and the CM2 had 5.0 ± 2.3 (2009) and 5.1 ± 2.1 (2010), and 7.2 ± 1.7 (2009) and 7.3 ± 1.5 (2010), respectively.

In general, data collected in interviews suggested a positive assessment in the use of this strategy, particularly because it enhanced the need to connect different concepts and facts studied during the undergraduate period that was not properly correlated in theoretical modules before practice in a hospital environment.

Despite the positive results, the mean score of grades were low in both groups performing the CM1. Based on the correction criteria (Figure 1) most students had the scores around 5.0, an insufficient performance according to the attribution of descriptive concepts. However, some students had excellent performance in both groups achieving the highest score also in CM2 as described in figure 5. In the CM2 performance analysis, 50% of students achieved scores above 7.0, a good score above the minimum required in the institution where the study was done.

However, during the years where CM strategy was applied 25% of students had scored under 7.0 for CM2, pointing out that more research related to this group has to be undertaken to assess interventient factors not covered in our investigation. In the literature most of the studies usually report users having difficulties to use this strategy (Derbentseva & Safayeni, 2008; Daley, 2004). Some of the most relevant difficulties are : little reflexive thinking style with contemplative characteristic about disciplinary contents; little experience with teaching strategies, requiring data search and interpretation process that establish links among them, which ends up resulting in decision-making. Results suggest CM helped to promote the habit of continuous reflection based on theory from a practical point of view.

Students concerned with knowledge acquisition develop more skills and are capable of adapting to any setting and proceed with ethical and innovative behavior when needed (Domínguez-Marrufo & Manzano-Caudillo, 2012; Cordeiro et al, 2012).

5 Conclusion

Students' performance and comparative analysis evaluation from the first and second CM seemed to enhance their ability to solve clinical cases during hospital practice experience. Surely, the experience acquired plus the theoretical basis improved the students' ability to think clinically because it enabled the development of subsumers, which is the final goal of this strategy.

Other factor indicated as interventient to get the skills to create the CM2 was the opportunity to sistematically analyze the relationship between different contents of several disciplines. It was also favored by the relevant data found, the nursing diagnosis and the perception of interventions.

Although, few students in both groups achieved an excellent score using the CM strategy, almost all participants agreed that it motivated them positively to develop clinical decision making skills. Despite the results of this investigation being positive, further work is required to improve the operational stages, other than those described here. Our strategy may enhance satisfaction level and help students to achieve better scores in exercises. This research suggests the importance of using concepts accordingly to the students' background before applying the first CM for clinical case correction, also the importance of delaying the use of strategies to solve clinical cases after hospital practice.

6 Study limitations

We lacked the quantification and discrimination of stages done during the strategy. Now we need a study to quantify the greatest difficulties faced in each stage part of the correction criteria. A challenge our research team has to overcome.

7 Future possibilities

Nowadays, we are developing an application software to help teachers to elaborate Clinical Cases and the Criteria for correction of Concept Maps. Our final goal is to provide the automatic correction, using the CmapTools^R in a new innovative way.

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CONCEPT MAPPING AND THE DEVELOPMENT OF ARGUMENTATION IN THE ZPD

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Abstract. A new strategy of organizing argumentative text and connecting this activity to concept mapping has been successfully realized through a series of recent experiments during curricular in-service activities with two groups of adolescent students of chemistry in the context of Case Based Learning. The preliminary results, along with the reasons and the conditions for taking advantage of the argumentation activity as a form of making and transforming newborn meanings, as well as of mediating an increase in the development of thinking in scientific concepts, will be discussed in comparison with concept mapping. The possible relevant role for concept mapping in the whole strategy will be also re-considered.

Keywords: Concept Maps, Case Based Learning, Argumentation

1 Introduction

The age called adolescence takes the child through a profound and qualitative evolution to thinking in concepts. This in turn makes the child understand him/herself as a thinking person, leading to a crisis in identity/personality, which also helps in building a world view, as occurs with gradual changes during adolescent's development (Vygotsky, 1998). There are many studies, including neurological (for example, see www.bbc.com/news/magazine-24173194), demonstrating that the way in which information is processed undergoes dramatic changes during the age of adolescence. These changes are certainly related to the way working memory is used (Baddeley, 2002).

Margaret Donaldson (1987, 1992) describes this stage of the intellectual development as the onset of the capability of the child to consider, or “observe” his own thinking on perceived objects or events, to listen to or read words, separate from objects or events denoted by those words. Vygotsky (1998) made a fundamental contribution in clarifying the essential role verbal (inner) thinking and social and cultural interaction play in the construction of meaning and in the development of adolescents' personalities. By combining Vygotsky's and Donaldson's ideas we can deduce that the changes in the speaking/thinking system of meanings (Mahn, 2012) are mainly affected by the use of language, over other minor factors. Words, as signs, are needed, consciously or not, to internally *control* the flow of images and to express innermost forms of meaning or representation, in speaking to and in interpreting other people's speech. Also, the mastery in the use of linking concepts (such as “because” and “although”, which were the object of empirical studies by Vygotsky, 1986) in everyday language and in the instructional environment, is highly related to the development of a new structure of thinking that is required to argue or reason.

Therefore *Argumentation* (not only scientific) becomes possible (but not necessarily actualized) as a result of these changes, because the related analysis, detachment, suspension of judgment, and order, are all consequences of the discovery that thoughts can be “captured” in different alternative forms, utterances, or *knowledge claims*, that may suitably carry different meanings, questioning, comparison and connection.

Before the development of thinking in concepts, spoken utterances and written claims reflect directly thoughts, where the most frequent connectors between the speech units are “and”, “then” or equivalent.

The zone of development for “thinking in concepts” represents, for the adolescents, the differential of the possible movements among different structures of generalization attainable with or without adult assistance. These structures of generalization range from the ones that are directly related to the objects and events (i.e. pseudo-concepts), to those which permit a free and deliberate use of abstraction or generalization, and operations such as differentiation and aggregation, as well as inverse operations of exemplification and transformation in terms of everyday concepts.

Everyday language is a way to think in “fossilized” structures, thus binding any development to possible changes in the cultural environment, whereas argumentation, starting from this *foundation*, can be not only a way to communicate, but also to “stretch” thinking & speaking towards the incoming and maturing higher order ways, in which the educational environment can make a difference. The modifying environment for the

achievement of advanced argumentation can be created as sets of structured activities, whereby the experience and the processes in using-sharing new “possible utterances” slowly shifts between the two levels:

Initial: verbatim-fragmented discourses with purely associative connections, lists of unrelated sentences or words, that attempt a direct answer to the problem posed; there is a tendency to take into account only a few terms of the focus-question at issue, because students have difficulty in considering the issue as a whole.

Final: highly connected processes of argumentation and synthesizing, that include an introduction or contextualization, a central and essential thesis, and a conclusion, where the different ideas are coherent to the sake of describing a whole structure, justifying a thesis or explaining positions linked by supporting evidence and causal or logical reasoning.

The adolescent-learners' zones of proximal development are processes in maturation somewhere in this interval. Given that argumentation is a sophisticated function of language, it is helped by reducing inquiry and epistemological challenge, while maximizing student-student interactions and dialogical function of language.

The language of *Concept Mapping* can be viewed as a further level of synthesis in respect to oral and written argumentation, as a concept map can be considered a dynamic source of possible spoken arguments. The concept maps that have been made after such a development has become possible, can be called “assertive”. Managing the further level of synthesis that is required in concept mapping is more difficult than in arguing because of a needed mastery in understanding and *transforming* the relationships between knowledge and concepts. The latter can be constructed to a deeper level thanks to oral and written collaborative argumentation as mediational tasks. Consequently, as long as the learner is unable to imitate a process of arguing, it is only possible to make a pseudo-concept map in which concept labels are connected by “assonance” relations, or they are simple classifications (whole-part relations), lists of feature words (as in mind maps), or reproductions of narratives in the X-Y plane (diachronic relations). Concept maps from students who have not developed argumentative thinking are invariably of this “descriptive” type. Even for skilled cmapper-teachers is quite difficult to respond to a “why-type” focus question, thus a partially descriptive structure is virtually unavoidable.

As we will see next, it is not necessary to add cyclic structures or to search for more complex structures in concept mapping, in order to give a concept map an explicative, mechanistic, or “demonstrative” function, because linearly written arguments can fulfill and scaffold these functions more easily.

2 Preferring argumentation as mediational strategy

The slow and written construction of coherent links between claims, warrants, and data, requires a voluntary “segregation” of what is being required in the task, to differentiate the generally different nature between factual data and claims. Therefore, the repeated application of this task and the progressive removal of teacher's support can help to extend the zone of proximal development of thinking in concepts over time.

Two different types of claims were elaborated: simple claims and combined claims. A combined claim puts together and links two declarations by means of a logical connector with the function of explanation (because), justification, support, hypothesis, if-then, consequence, adversity, or simply time-narrative value.

One of the most difficult subtasks in the construction of written arguments is to create the connections between different claims in the perspective of the coherence of the whole text. Only an overt discussion with the help of teacher during the “work in progress” permits the possibility of choosing a better amalgam between several “local” meanings and to better address the whole argument towards the focus question.

The meaningfulness of an argument is displayed at every level: it is in the argument as a whole, in every aspect of a complex argument, in a combined claim, in the specific and contextualized use of every concept in making a claim or proposition. Every level of meaning can be the object of collective-dialogical reflection and can be given a name and a connotation in the process of shared revision, in order to stimulate the development of higher structures of generalization. It is evident that this is a second level of the process to support a written or “objective” argument, which would be impossible to get during a live class debate aimed to argue an issue.

Debate and negotiation-structured activities have been applied, especially in the first part of the project, as a way to orally defend and self evaluate the arguments that were created by the teams in the classroom. These activities resulted as a very useful way to instill a constructivist atmosphere in the whole learning community

and to provide a sociocultural frame for the process. However these activities, accompanied by the “fast-thinking” processes of speaking, are not suitable, or too time consuming, to solicit changes in the voluntary use of the logical connectors and of the meanings associated with scientific concepts; these are indeed two changes which actually demand *slow & conscious* processes, as is viable in written activities. These latter processes are also more demanding in the use of working memory, and this is a further reason to use an objective-written form of argumentation as a mediational base for working in the “higher” zone of development. In fact, in contrast with the discourse-flowing claims the written claims and concepts can be more easily treated or flexibly disembodied as separate objects or ‘chunks’, and grouped back again in new and different ‘blocks’.

A typical function that is demanded of the students is to “detach” themselves from the text and see it from the point of view of a proofreader or another student-reader. This is a very metacognitive function that entails the previously stated flexibility in order to consider different levels of the argument at the same time, and can produce deep revisions in the sequence and structure of text claims.

One reason to prefer argumentative structures to concept maps in the early stages of shared construction of new knowledge is the fact that the structure of written claims is at first similar to the logical structure of oral discourse, that is mostly linear - narrative - thus allowing students to directly capture and retain those utterances, from both the internal and external discourse, that can be mentally re-echoed, shared at different times and transformed, or checked, as internal speech toward an imaginary third person (the listener-proofreader). School tasks of re-reading/reviewing linear texts are more generally trained & accepted tasks than concept mapping.

Another reason for this preference is that written argumentation have the largest degree of freedom in repeating the use of the same concepts and in the choice of logical connectors between claims, including those consequential, adversative or if-then and phrasal structures that are notably tricky to arrange in concept maps.

3 The structured argumentation task in detail

One of the most striking pieces of evidence that the process of argumentation fits the ZPD of adolescents is the observation that the teacher’s *efforts* to obtain good written arguments, following certain rules, rapidly decreases from age 16 to 18, tracking the three years of taking courses in chemistry. The encountered difficulties were highest with cause-effect types of argument and lowest with mostly descriptive arguments.

The following - very good - structured argument was “distilled” in an activity (the third of this kind in the year) about ‘carbohydrates’ in the fourth high school grade. A group of five students (each one coming from a different stable team) first searched for information related to the general topic that was assigned (Topic 1: “The ‘Reducing Power’ of carbohydrates and the oxidation products”). After the material was assembled by the group members in a Google document from home, the five elaborated the answer to the focus question as a structured argument at school, in a two-hour class. There were two more topics and related focus questions that covered the whole study of the sugar module, and these were assigned to the other two groups. After his/her job on the focus question, every member returned to their original team; there the specific knowledge was shared, and three concept maps were collaboratively constructed that answered the same three focus questions. Then three teams were chosen to present and discuss the final Cmaps to the class. All the 15 cmaps were rated.

FOCUS QUESTION 1: Why is also the ketone group of ketoses easily oxidized?

Argument:

1. To consider a sugar as “reductant”, it must be oxidized by weak oxidant agents in basic milieu. This occurs **if the condition is met** in which the sugar molecule is in equilibrium with its open-chain form, **because** the latter is the only one with the free-oxidable carbonyl.
2. In a basic milieu, weak oxidants as Ag^+ and Cu^{2+} ions, contained in the Fehling’s, Benedict’s or Tollen’s reagent, can oxidize to gluconic acids aldoses and ketoses as well, **because** the latter are “epimerized” to the former in basic solution.
3. **By contrast**, only aldoses can be oxidized to gluconic acids (carboxyl in C1) by weak oxidants, as bromine water, $\text{Br}_2(\text{aq})$, **if** oxidation is operated in non-basic solution, **because** the aldehyde group only is easily oxidized in absence of epimerization.
4. In epimerization a base subtracts a proton from C1 yielding a symmetric enolate, in which the OH on the C1 can protonate the equivalent -O that can be obtained in C2 by resonance. The new enolate-carbanion in C2 is **then** back-protonated to aldehyde by a water molecule.
5. *[new claim to be added by the group]*
6. All sugars are **then classified** as reductant, **except** those which lack a free anomeric hydroxyl, as glycosidic sugars and polysaccharides. In the latter the unique reductant site, *at one end of the chain*, is not analytically detectable.
7. **Indeed**, any sugar that hasn’t been classified as reductant can be oxidized, by strong oxidants as nitric acid, to aldaric acid, which have carboxyl groups at both chain ends. **Unlike** aldoses, the carbonyl function is kept by ketoses when they are oxidized to aldaric acids.

A few words must be said about this example *structured argument*. Contributions by the teacher were given as advices, to split some complex claim, to change the sequence order for better adhering to the focus question, to eliminate something that was not relevant, to introduce and summarize the complex mechanism in the fourth

claim. All these hints were negotiated within the group and actualized by the group autonomously. During the process of accomplishing the task, it was clear to the learners that an ‘imaginary non-expert addressee of the argument’ was ‘present’ in the class. Hence the claims ought to be detailed enough to avoid ambiguity, misunderstanding and shortcoming to this ‘person’. Although the material that the students had collected before was really detailed with images and examples (e.g., reaction mechanisms and chemical formulas), to stimulate the use of the most *general* concepts, students were told to use *only words* to construct the argument, and minimize the use of specific examples. Those would have been useful in the concept mapping stage. The few *italics* words were added by the teacher, who also pointed to a missing link in the chain (why free anomeric hydroxyls make the ring openable) that ought to be fixed (claim n.5). For the sake of this article, the ***connecting words*** have been put in bold. These words represent the “welding joints” to yield the meaning of the composed claims and of the whole structure, but are almost untreatable in making concept maps’ propositions.

The process steps and criteria to adopt in writing a structured argument are the following.

1. A clearly stated focus question on a very precise and primary issue - not but the overall topic - is assigned.
2. The “answer” cannot be given as a single short sentence or declaration, but as an articulate argumentative text.
3. The argument has to be divided into separate and numbered knowledge claims or ideas, expressed in simple sentences or propositions with subordinate clauses, examples, etc. that, in any case, shouldn’t go beyond three lines of text.
4. Every logical connector must be explicit, within the combined claims (e.g.: ‘consequence’ *because* ‘cause’) or at the beginning of every new claim.
5. A structure can be given to the argument with a necessary contextualization or premise, a main body, and a conclusion, in such a way to form a complete, connected, and coherent text that can be read as a meaningful whole.
6. concept-labels have to be highlighted in two different colors to select and distinguish a few first-level concepts and a larger number of second-level concepts (those concepts that can be directly connected to the former).

Point six was to prepare the concept-mapping activity. If an argument requires more than a dozen knowledge claims, or more than 20 concepts, it should be split into sub-arguments. In any case, the focus question is always designed to tackle a restricted and yet representative section of the whole topic (a criterion that, incidentally, should be used also in normal concept mapping). This has the function of avoiding purely descriptive answers, or simple lists of facts or events, and of demanding explicit recourse to the scientific concepts and to the functional relationships between them, as well as to a reflection on the new and often unfamiliar related terms.

The strategy is concocted to push the integration of the new, scientific terms in the construction of "natural" sentences, at least from the point of view of syntax rules of normal writing and speaking. On the other side the unnatural set of syntax rules of concept mapping constitutes an obstacle to this sort of stretching from the everyday to scientific discourse, which is aimed in the early stages of tackling new scientific-conceptual domains. Where efforts are not made, or if they are unable to stimulate this kind of integration, the new terms and concepts are only assimilated and re-evoked as “stock phrases” utterances.

4 Forms of training and mediation

In order to facilitate the understanding of the new task of creating an argument as an answer to a focus question to the student teams or to the individuals, several strategies have been used at different times.

- a) video examples (http://youtu.be/raG5cm_tdt4), constructing examples or discussing a previous examples in the classroom;
- b) from a descriptive textbook page, eliciting the useful parts (for a premise, for the main answer, for the conclusion or a question);
- c) selecting the first & second level concepts from a given argumentative or descriptive text and then comparing them in the class;
- d) very simple focus questions on familiar content were assigned to answer with at least two levels of causality. In two cases that task was used as an assignment to assess the progress in the collaborative and argumentative skills of the teams. A *rubric* (available on demand) was used for the assessment with five 1-3 ranks for: a) respect of form-structure of argument; b) completeness-adherence; c) cohesion; d) internal coherence; e) adoption of pertinent concepts.
- e) A long chain of causative connections was used to explain in front of the class why one of two acids is stronger than the other, by means of theoretical reasons, starting from *bottom-up* (from primeval causes to the consequences). Everybody was allowed to check the comprehension of every single step. Only the structural or symbolic representations of the (familiar) causes/effect concepts at each step was left on the blackboard, with simple arrows connecting the sequence (instead of the spoken argument). After that, the teams were asked to collaborate to answer the question “why is acid A stronger than B” with a *top-down explanatory-chain argument* (from the effect to be explained, backward to the causes). The argument-answers were then anonymously handed out to the other teams to count the number of explanation steps and to report possible errors. The anonymous answers were digitalized, prompted by the teacher and shared in a web document to the whole class for the sake of critically fixing the prompts.
- f) in the most resistant-to-treatment cases of causative-explicative chain arguments, a complete sequence of shuffled subclaims was given with the task of reconstructing the right sequence. A similar task was to insert the missing connective words to complete the argument made of cause//effect pair of clauses. The linking words were to be created in one case, and to be taken from a list in the easiest case.

The kind of feedback given to the individual learners or teams, depended on the demand of revision of the spontaneously-constructed arguments and this was determined, in turn, on the large differences in the development of conceptual thinking and in the quality of the arguments that the students elaborated without assistance, at different ages. Therefore, it is worth reporting the most frequent demand of feedback in the two different classes (third grade, 16 year olds and fourth grade, 17-year-old students).

Most frequent demand of feedback in third grade

- a) The meaning of some term was reported from Wikipedia instead of answering a very precise question (the focus question was not considered in its detailed meaning, but as a “hint to talk generally and freely of a certain subject”).
- b) “False claims”: list of non-predicating concepts or data are given instead of knowledge claims or assertions.
- c) Lack of analysis: an answer is given as a single undivided block of text.
- d) Lack of coherence: isolated blocks of information about some scientific terms, with mixed expository, descriptive or expressive texts.
- e) Causes are mistaken with effects and other logical inversions
Just one real example among many: “Dichloromethane molecules are more polar because dichloromethane is the most water soluble of three liquids” = a consequence has been put forward instead of a more profound cause.
- f) The same phenomenon to be explained, or an equivalent one, is adopted as an explanation.
These are just three real examples, taken from dozens. a) Focus question: “why is water a so polar solvent and capable to dissolve salt?” Single line answer: “because water is highly polar” (no comment necessary); b) “What explains why the retarding potential which stops the photoelectrons does not change if light intensity is increased, is precisely the fact that light intensity does not affect the energy of the emitted electrons.” The explanation sentence is equivalent, as a relationship between *facts*, to the phenomenon to be explained that was stated in the first clause. It lacks any *theoretical* aspect connected with the nature of light, which should have been adopted as an explanation, but was owned by the student as *inert knowledge*; c) an answer by a three-student team: “In our experiment we have seen that dichloromethane is the most soluble of the three liquid chloromethanes, because its solubility amounts to $13 \text{ g/L} > 8 \text{ g/L} > 0,8 \text{ g/L}$ ” (the fact is happily explained by the fact itself, with scientific aplomb!)
- g) A false connection with a true claim is adopted as a warrant
Example focus question: “Why does your textbook consider ionic bond not really a bond at all?” True Argument: Textbook says that ionic bond is not a true bond because that bond is just a union of two elements with opposite charges. I think, on the contrary, that that is a true bond because it permits to the two elements to obtain stable configurations. Thus, it’s a mistake to say ionic aren’t quite true bonds.” This is a good example of arguing, but the student considered the stable configuration as essential in bonds, instead of taking into account more concrete features as the capability of the “elements” of sticking to each other, determining a stable composition.

Sometimes clarification issues have been made after the analysis of the misconceptions in the protocol outcomes, with poor, if any immediate results. An example is given here of point e), about the concept of *evidence* as a link between theoretical-hypothetical and factual claims:

Clarification 1 [Teacher]: “Not everybody grasped the asymmetric relations”:

$$\begin{array}{lcl} \text{“Evidential Element } \square \text{ testifies to, or proves} \rightarrow & & \text{Hypothesized Crime”;} \\ \text{“Change in Observed Properties } \square\square\square \text{ is an evidence of } \square\square\square \rightarrow & & \text{Structural Change”;} \end{array}$$

These claims are right. But you cannot say, as somebody did, that those claims are equally correct:

$$\begin{array}{lcl} \text{“Structure Change } \square\square\square \text{ is an evidence of } \square\square\square \rightarrow & & \text{Change in Observed Properties”;} \\ \text{“Hypothesized Crime } \square\square\square\square\square\square \text{ proves } \rightarrow & & \text{Evidence of Crime”}. \end{array}$$

The existing structure of generalization of pseudo-concepts is still dominant and this prevents the youngest adolescents from voluntarily and autonomously working out a difference in the hierarchy of concepts, or distinguishing what is factual from what is theoretical, when these concepts as “structural change” and “observed properties”, are not immediately objective or familiar, thus making whichever relation between them equally allowable. Nevertheless, these distinctions can be made thanks to the assistance of teacher-mediation, leading *in the long term* to the development of autonomous conceptual thinking. What should be absolutely avoided is to believe that if the learner utters or writes the same terms that correspond to the scientific concepts of the teacher, in spoken, written language or concept maps, then that learner has a conceptual understanding.

Fourth grade. The most frequent feedbacks were to...

- a) signal the need for explaining the meaning of a concept by means of a claim;
- b) signal the lack of a connecting link (a concept or a knowledge claim);
- c) propose a change in the knowledge claims’ sequence to keep closer the most interrelated concepts or sub-arguments;
- d) establish a connection, a comparison, a causal link, etc., between two or more claims;
- e) going back more often to the focus question, to re-evaluate the whole argument or an overlooked aspect of it;
- f) split a complex knowledge claim into simpler ones, giving also a criterion if needed;
- g) advise a change in the division of claims, by means of a different criterion of using a hierarchy of concepts or a new general concept;
- h) review one particularly weak part of the argument.

It can be appreciated that these interventions were always to adjust a regular process, but *never* to make the task simply feasible, or understood, as it was needed in the third grade class.

5 Collaboration and application examples

The written & collaborative argumentation activity was originally planned as an extension of the advanced ALCA protocol (Academic Language of Chemistry for All, Tifi, 2013), a protocol that was derived from Mahn's ALA protocol (Mahn, 2014) as suggested by the many similarities between the task of extending the ZPD of adolescent learners of a second language and that of adolescent learners of scientific literacy and of language of chemistry. The protocol was to support the mastery of systems of general-abstract concepts that were emerging during the laboratory study-of-cases activities, but in the second part of the year it was adapted to empower conceptual thinking and reflection about topics that were theoretical from the beginning. The following plan was devised to maximize individual reflection, face-to-face interaction and peer discussion, and was applied several times, until the students mastered and appreciated the rubric to rank the others' arguments - presentations.

Starting from a specific focus question as prompt,

1. At home. In a Google document, capture individual ideas and concepts in numbered short sentences, and share them with the teacher;
2. At home. The teacher collects groups of four answers in single documents and extends the sharing of the four partially structured answers to student pairs for next step. Every two students review their own answers, together with the answers of two anonymous teammates.
3. At school. The two pairs of every group of four are reunited to work in a document with the reciprocal revisions, original answers and concept lists. Then, they have to reduce to the minimal essence the single agreed argument-answer that will be presented to the class;
Before the next turn, the teacher checks that every peer group correctly isolated the concepts that will be used in the answers, and prepares a table of these concepts of all groups, inviting them to edit their own concept lists, and to prepare the speech to defend their answer (step 4).
4. At school. The table of concepts that have been used by each peer group is showed and compared, while each group tells the class from memory how they answered the focus question, and then they defended their view by answering the questions that the other groups asked within a limited time. The knowledge of concept meanings can also be checked by the questioners. At the end of each presentation, the answer and conceptual knowledge are rated by an objective scale:
5 pts: the answer doesn't need any change or implementation; any objection have been rejected with grounded motivation
4 pts: the answer and concepts were questioned, but the presenters were able to adjust and adapt it at the moment
3 pts: the answer was challenged and the group replied to it, but it still seems that something should be changed or reviewed
2 pts: the answer was subjected to criticisms and the defenders overtly need more time to reflect on it and adapt it
1 pt: the answer was judged incorrect in some fundamental points, but the defenders don't accept-recognize that corrections are necessary
0 pts: The answer (concepts included) is completely or partially missing
the rating is agreed within each peer group, and then assigned in a overt poll.
5. At home. The best rated structured-answer & related concepts are shared in the four peer group documents and each peer group is called to edit their own as turned out in the presentation step and then to transform it in an argumentative sequence and as a Cmap.

The following is a teacher's report of one application of the protocol to the general task of "what determine the identity of a substance", after several experimental cases were studied.

"What happened during the first 4 steps is that the teacher himself became more aware of the structure of the system; some useful concepts emerged, as 'chemical behavior'. This simple realization helped to put other measurable physical properties (e.g. b.p., m.p., refractive index etc.) in the correct scheme or cmap of characterization of a substance. All these concepts could be collected under the new root concept of 'characterization' of a chemical substance, comprehending composition, structure, physical properties, chemical behavior. This augmented awareness of the teacher a) is part of the constructivist game of creating a 'local' academic language, starting from the students everyday language, b) it can be transferred to the students, and this corresponds to extending their ZPD and, c) it leaves a higher level of know-how and deeper understanding to the teacher too. These three points demonstrate that in the ALCA protocol the intervention of teacher in helping the construction-reviewing of the answers or challenging the most 'dangerous' misconceptions is a very important element of the process."

The following concept map was made by one team in a related activity about 'evidences of chemical reactions'.

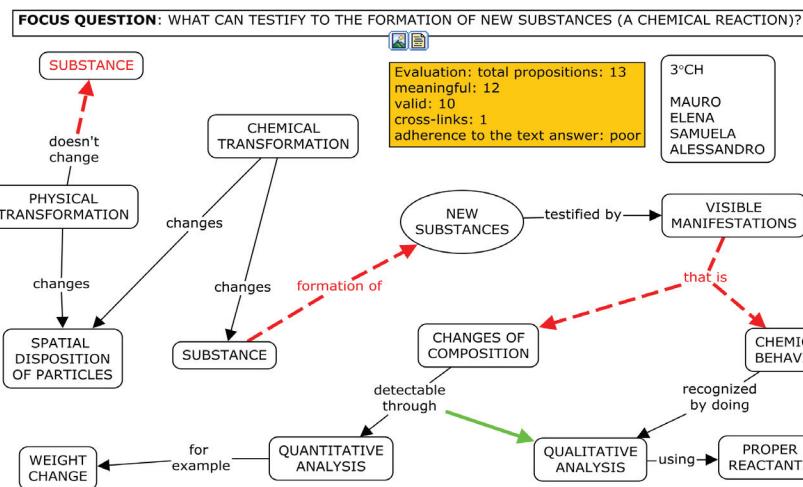


Figure 1: Concept map constructed by a team after the protocol ALCA. The correct idea that changes of composition could be revealed by qualitative analysis was considered a “happy” cross link because it demonstrated a newborn concept-association. “Adherence to the text answer” is a rough indication of the correspondence between the answer as written argument and the corresponding cmap.

Would the students learn abstractedly a pre-made scheme, maybe they would have got a better mastery of the scheme’s words, but not of how to use these words to make sense of real-world instances and to re-evoke their previous experience. We can adopt “concept shaping” in referring to mental processes for conceptual change, differentiation and adaptation, as different from “concept mapping” intended as a process of externalization of pre-existing conceptions. The two are diverse only on a quantitative basis. Concept mapping on paper or screen, as well as construction of written and shared arguments, is not only ‘for others’, as much as concept shaping in the mind is not only ‘for oneself’. The two are both for creating new concepts as well as for raising awareness of old concepts. Both are not completely transparent and conscious processes. Concept mapping and written argumentation are more likely to be authentically transparent (i.e. to constitute a representation of the system of concepts of the learner and of the terms and concepts that he would really use spontaneously in other contexts), if they have been preceded by some activity that socially triggered “concept shaping”. This is just another way to consider the interaction between internal and external discourse that has been mentioned in the 2nd paragraph.

A different protocol was adopted for a shorter activity on the chemical bond.

Individual Phase (every member of the team choose a different focus question)

- 1.1 Read paragraphs 1.2 and 1.2 at page. 3, 4, 5 of the textbook (Organic Chemistry) and then read the focus question.
- 1.2 Select the useful and pertinent parts of the text
- 1.3.a Write the answer as short knowledge claims of 1-2 lines to set a context that is useful for the focus question.
- 1.3.b Add more knowledge claims chained and numbered in a logic way, to complete the development of argument
- 1.3.c Select the concepts of first and second level that will be useful in the construction of a concept map.

Group phase

- Collaborate in the construction of the Cmap within the teams which dealt with the same focus question (*Cmap hyperlinks in parentheses*)
- 1) Why is the formula of lithium sulfide Li_2S ? (<http://goo.gl/LHPbgb>)
 - 2) Why does your textbook consider ionic bond not properly a chemical bond? (<http://goo.gl/3B5Ykf>)
 - 3) Why is the carbon disulfide liquid and why its water solution hasn’t an increased electrical conductivity? (<http://goo.gl/g2Cxoo>)

The concept maps retain some interesting features from the derived arguments, showing that some connecting words can be implemented (demonstrate, therefore, because, consequently, for the sake of, thus) in the cmaps.

The last case of the year studied experimentally the reaction of limonene with bromine; it was preceded by a theoretic study of the general mechanism of electrophilic addition to alkenes, with the following plan.

1. At school, the teams answer a quick questionnaire to contextualize the argumentation topic, and then start to answer the following focus question: “How does the reaction mechanism of the electrophilic addition to alkenes explain Markovnikov’s Rule?”
2. The teams’ arguments are given feedback by the teacher and edited until satisfactory. Then concepts are highlighted, ready for the cmap.
3. concept maps are made individually on the basis of the team argument.
4. Pros & cons of some arguments and cmaps are analyzed and discussed in the class.

This activity resulted in interesting insights because the two parts of the focus question were easily attainable if set apart, but the conjunction of the first part (reaction mechanism) as a causal explanation of the

second (Markovnikov rule) was hard to put in words, whether in the phase of constructing the argument or in the concept mapping individual activity. A complete argument and derived concept maps are shown in closure.

Team B answer-argument (first level concepts are double underscored, second level are single underscored; connecting words are in bold type).

1. The alkene is attacked first by the electrophile part of the reactant, in the mechanism, **because** it is a nucleophilic substrate.
2. One bonding pair in the double bond is used to covalently tie the electrophile to one of the two carbons; **consequently** the other carbon becomes positive, as part of a extremely reactive species (**because** the positive carbon doesn't reach the octet), called carbocation.
3. Among the different possible unstable carbocations, is lower in enthalpy the more substituted one, **therefore** the effective impact between alkene and electrophile will require less energy if the most substituted carbocation will be formed as an intermediate.
4. Thus a lower energy barrier to overcome would **imply** a decidedly higher rate of conversion when the reaction passes through the most substituted carbocation.
5. The most substituted intermediate carbocation is the only formed in significant amount, **therefore** the nucleophilic part of the reactant will be bonded to the most substituted carbon, as the Markovnikov rule established.

The Cmaps by E.C. (<http://goo.gl/WRwhDY>), more tied to the sequential structure of the reaction mechanism in the argument, and by A.Z. (<http://goo.gl/NY9dx1>), with more descriptive content, have been translated. Every individual concept map was reviewed by the teacher and discussed individually with the students, or in interactive discussions in class. Several students made new versions with less errors, after the revision.

6 Conclusions

The greatest effort in this first part of the experiment was devoted to the development of a series of strategies to implement and evaluate the construction of written argumentations as a *generalized* form of mapping concepts and transforming complex meanings (*concept shaping*). Therefore, the training and scaffolding of concept mapping was somewhat sacrificed, although many concept maps were skillfully constructed by individual students, groups and stable teams, sometimes with noticeable quality and effectiveness. The structured argumentation activity was thought from the very beginning as something to be coupled to concept mapping; more ideas about the way of coupling emerged along the way.

A possible next step in this research, would be to highlight concepts in the written argument primarily as a way to augment awareness of the concepts and their role and differences, and to favor the cognitive functions of disembedding and generalizing, leaving the students free to adopt and adapt or not the same concepts in making the cmap, as well as to add more examples and different resources.

The further contributions to the extension of ZPD, to the development of thinking in concepts and of meaningful learning, that is expected by the concept mapping process, will strictly depend on the system of activity which is entailed in the learner-cmapper process (Aguilar Tamayo, 2006). This system is in turn “prepared” and empowered by collaborative and teacher-mediated construction of another kind of textual artifact, which has been called ‘structured argument’ in this exploratory research.

While concept mapping can be considered as a sort of crowning activity, and an integration of multiple pathways and tools to operate a further synthesis in the *final* part of the learning process, it manifests a limit in reflecting and accompanying the “work in progress” of conceptual development, because of its excessive distance from the inner and external discourse, and because of its “syntactic hindrance”.

These limits can be balanced by alternative *propositional* artifacts, based on knowledge claims that are more flexible and suitable for the *core process* of conceptualization.

Whereas the written arguments are destined to subside once they have performed their function of driving disembedded thinking, objectifying ideas, and stimulating reflection, the role of concept maps remains undisputed as supporting a synthetic portfolio of competencies, intended as a set of retrievable conceptual structures which the learner has mastered and can be able to master again.

The integration of the individual and collaborative activity in the combined proposal, on the other hand, warrants a high degree of sharing and inter-subjectivity of such competencies. In this respect, the cmaps edited by the students and teacher can be a profitable and further source of stimuli to the sharing of competencies.

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CONCEPT MAPPING AND UNIVERSAL DESIGN FOR LEARNING: MEETING THE NEEDS OF LEARNER VARIABILITY IN EDUCATIONAL ENVIRONMENTS

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Abstract. Fashioned through the work of Joseph Novak's original theory of meaningful learning which states "meaningful learning must underlie the constructive integration of thinking, feeling and acting if learners are to be successful and achieve a sense of empowerment" (Novak, 2010:132), this paper is based on the assumption that learning is very complex involving cognitive processes, conative and affective factors. Furthermore, through research and principles related to the Universal Design for Learning (UDL) framework for meeting the needs of learner variability by designing flexible learning environments (Rose and Meyer, 2000a; Rose and Meyer, 2000b; Rose and Meyer, 2002), this study reinforces Novak's original theory underlying Concept Maps and will discuss that the use of Concept Maps as not limited only to cognition, but involving other important, underlying mental processes such as conation and affectation. Consequently, Concept Mapping is a robust tool, which responds effectively to the learner variability present in classrooms to yield meaningful learning.

Keywords: Concept Map, Universal Design for learning, Meaningful Learning

1 Introduction

The field of education is constantly evolving and we are at a pivotal point of change in the twenty-first century. The learning sciences have demonstrated a need for more flexible learning environments that provide versatility in how learners learn and educators teach to account for variability among learners. As the landscape and goals of education are shifting, so too is the approach to teaching diverse student populations. One way to achieve the flexibility that is needed to provide access for all learners to curriculum is through Universal Design for Learning (UDL). UDL is a pedagogical philosophy that is rooted in modern advances in understanding how the learning brain works. Rather than adapting or changing learners to best fit curriculum (curriculum as defined by: goals, materials, methods, and assessments), UDL focuses on how to build flexible learning environments that prioritize access for all, from the point of design, rather than as an afterthought (Rose & Meyer, 2000a; Rose & Meyer, 2000b; Rose & Meyer 2002; Meyer, Rose & Gordon, 2014). One way to build a flexible learning environment is through the use of Concept Mapping (Novak, 2010) as a tool to respond effectively to learner variability. When Concept Mapping is used to activate prior knowledge and to allow for learners to engage in their learning process by starting from what they know rather than from where the teacher dictates, Concept Mapping provides a more flexible and customizable approach to learning. This notion of fostering engagement in learning is a core component of UDL that functions as a way to address learner variability. From a UDL perspective, thinking and learning are considered to be dynamic interactions of both emotion and cognition (Meyer, Rose, and Gordon, 2014).

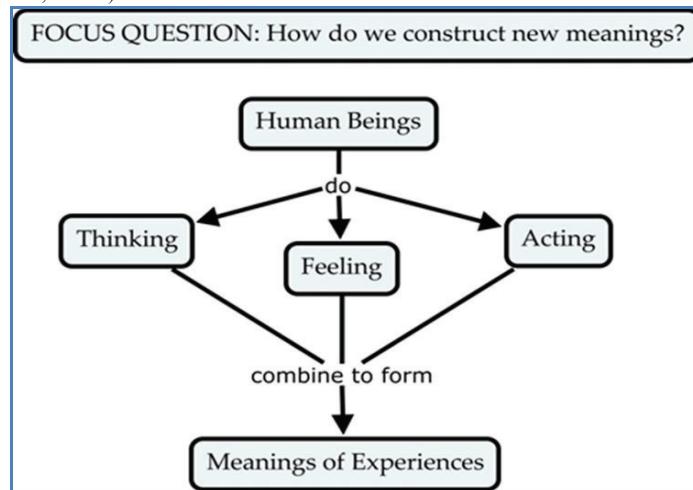


Figure 1: The meanings we construct from our experiences are a composite of our thinking, feeling and acting during the experience.
 (Novak, 2010:14)

Fashioned through the work of Joseph Novak's original theory of meaningful learning (Novak, 2010; Figure 1), this paper is based on the assumption that learning is very complex and involves cognitive processes, conative and affective factors. Furthermore, through research and principles of Universal Design for Learning (UDL), this study will reinforce Novak's original theory underlying Concept Maps and will discuss that the use of Concept Maps as not limited only to cognition but as involving other important underlying mental processes such as conation and affectation. Consequently, Concept Mapping is a tool that responds effectively to the variability of learners present in classrooms, with a view to yielding meaningful learning.

2 Learner Variability

Learner variability may present itself in the form of various factors such as differing thoughts, feelings, and ways of performing (Matthews et al, 2000). For instance, Brain (2000) suggests that while some incoming information is selected for attention, other information may be neglected. Brain's work on how information is received is built upon both Broadbent (1958) and Treisman's (1964) models, which show that information enters the senses through a 'sensory buffer' where the information is selectively filtered. This selectivity view is also presented in Sousa's (2006) model. The way in which an individual perceives a situation can differ based on a number of variables that can shift or change the point of initiation for that experience. Affective responses to experiences can physiologically change a learner's performance (Immordino-Yang & Damasio, 2007) and these perceptions are considered as initial points of engagement or disengagement for learning (Meyer, Rose & Gordon, 2014) that can skew a learning experience even before it occurs.

Many theories of learning further distill the emotional and cognitive influences on learning. For instance, Dweck & Masters (2008), Brophy (2010) and Forsten et al (2006), reveal how learners can interpret and respond differently to learning experiences in the face of challenge. The appraisal of a situation will determine how learners feel about a situation, that may impact their performance. Marshall Shelton & Stern (2004) also suggest that having teachers who are attuned to understanding feelings, referred to as "emotional information," would increase the effectiveness of teaching and student learning. Other authors such as Matthews et al (2000:16) state that there are differences in "*stylistic variables such as willingness to respond and preference for speed over accuracy.*" It is worth mentioning here that in most of the literature, factors contributing to learner variability were discussed as disparate units in the brain although they all seem to play a major role, in one way or another, in the learning process.

Historically, different biological functioning could be mapped to different regions of the brain. Though the structures of most human brains are anatomically similar, the patterns of neural connections tend to vary depending on previous learning, experiences, or preferential tendencies for learning across domains. Current studies in neuroscience have shown these dynamic examples of variability among learners by focusing on learning as more than just singular points of neural activity in the brain for any one task, but as connected neural networks (as explained in Meyer, Rose & Gordon, 2014). The white matter, or connective tissue, in the brain forms complex webs or networks. When learning occurs, the brain changes; however, specific points of neural connectivity do not change, the networks that surround them do (Meyer, Rose & Gordon, 2014). Based on the type of task being performed, there are regions of the brain that we can predict will be activated, though educators must consider that variability within networks will be based on a number of variables that are dependent on individual learners within different contexts.

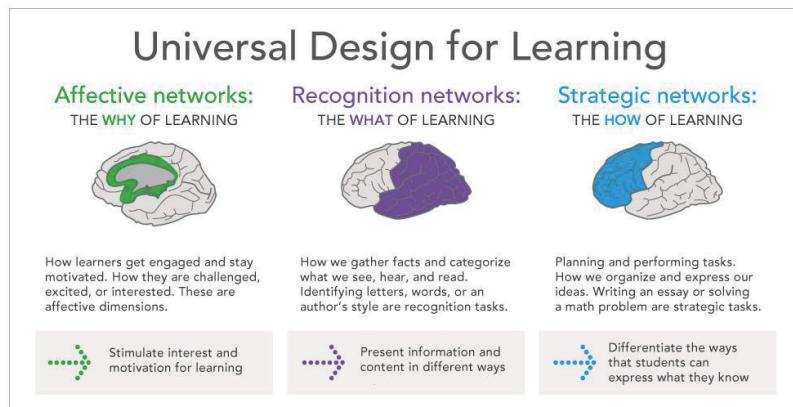


Figure 2: The brain networks (CAST, 2013)

3 Universal Design for Learning (UDL)

Universal Design for Learning distills empirically based, best practices from cognitive neuroscience, the learning sciences, and educational psychology, into guiding principles that support the pursuit of expert teaching and learning (Meyer, Rose, and Gordon, 2014). Seymour Sarason posited that the “*features of classroom contexts of productive learning means that teachers will be using their time in ways that make the concept of respect of individuality other than empty rhetoric and pious sloganeering*” (Sarason, 2004). Inevitably, there is a need for teaching and learning to be redefined in terms that address the entire learning process and promote not only cognitive acquisition and demonstration of knowledge, but also the engagement in meaningful and purposeful learning. Though the perceptual shift is slowly infiltrating educational systems globally, the need for more flexible learning environments has remained constant in both Novak’s Concept Mapping and CAST’s UDL theories and initiatives. Invariably, learning is a complex system where thinking, feeling, and doing are intertwined both neurologically, and in practice (Meyer, Rose & Gordon, 2014; Novak 2010). Concepts and current findings in neuroscience, along with fundamental principles of learning and development, imply the notion that variability is inherently present in how individuals learn, and educators must adapt practices to best meet all learners’ needs.

Keeping in mind the goal of developing opportunities for all learners to experience purposeful, meaningful learning, the creators of UDL recognize that equity and opportunity for learning may not always result in equal pathways for learners to accomplish any one goal (Meyer, Rose & Gordon, 2014). When flexibility and options to reduce barriers in order to access curriculum are established from the beginning of curriculum development and implementation, the purpose of learning experiences shifts from focusing only on content attainment and expression, to having learners engaging in meaningful (Novak & Gowin, 1984; Novak, 2010), expert learning (Meyer, Rose & Gordon, 2014). Similar to the work of learning theorists like Lev Vygotsky (1978) and Benjamin Bloom (1984), guiding principles for UDL are established through a three-part framework. UDL is focused on creating access through three primary learning networks in the brain: affective, recognition, and strategic networks (Figure 2). The provision of options to recruit learner engagement (motivation and connection expressed toward the process of learning), representation (how students receive information or content), and expression (how students demonstrate what they know) (Rose & Meyer, 2000a; Rose & Meyer, 2000b; Rose & Meyer 2002; Meyer, Rose & Gordon, 2014) strive to activate and initiate all three networks in concert with one another to lead toward expert learning. By building flexible learning environments that consider differences in experiences across contexts, with a predictable range of learner variability, customization of resources can be possible at the point of design, rather than retrofitting, or creating scaffolds in the moment to only support individual learners during implementation (Meyer, Rose & Gordon, 2014).

As a way to support educators to consider variability in learning environments, CAST developed a set of guidelines (Figure 3) based on the distillation of a vast body of work that focused on empirically validated research, approaches, or interventions to foster meaningful learning to highlight areas that may present barriers to learners accessing curricula. The UDL guidelines were created as a blueprint for educators and curriculum designers to consider options for the optimization of learning environments. The UDL guidelines provide concrete examples, through checkpoints for each principle, along with options for best practices to consider flexibility for all learners. Similar to the process of using concept maps as a formative process to monitor learner progress, using the guidelines as a lens for educational practice, allows educators to constantly monitor their own progress by systematically choosing options embedded in “UDL-ized”, flexible curricula, for in the moment customization of learning experiences.

Universal Design for Learning Guidelines

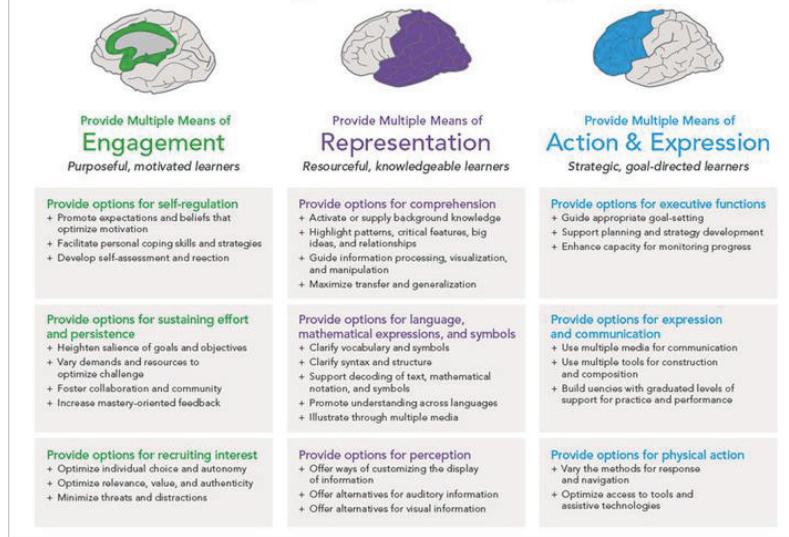


Figure 3: The Universal Design for Learning (UDL) Guidelines (CAST, 2013)

For the purposes of this paper, the goal that seeks to be achieved in considering UDL as a framework for curriculum design is to achieve meaningful, expert learning. In order to be an expert learner, individuals need not only to have expertise in any singular domain, but should possess the skills to be resourceful, strategic, and purposeful when learning across contexts and domains (Meyer, Rose, and Gordon, 2014). Similar to Novak's original theory of meaningful learning; as interactions between thinking, feeling, and doing, expert learning is presented as the goal for activating the three learning networks in the brain through opportunities to refine the best practices of teaching and approaches to learning (Meyer, Rose, and Gordon, 2014).

This paper sets out to strengthen the argument that variability is inherent in learning environments (Meyer, Rose, and Gordon, 2014). To account for such variability, educators can explore what it means to be engaged in meaningful and expert learning to provide options for learners to work toward their goals. We believe that one of the tools to facilitate meaningful and expert learning is through the use of Concept Mapping. Concept Mapping can provide a flexible demonstration of learning through the identification of options needed for curriculum enhancement, while responding to learner variability. Not only do concept maps allow for options in representing the knowledge which is meant to be learned, they also provide the monitoring of progress through further expansion of propositions and concepts developed, or established during the actual learning process. Furthermore, this process can also activate a sense of engagement and autonomy as the independent "maps" of an individual's learning process are visualized through this interactive tool. Intersections between UDL and Concept Mapping become illuminated through the philosophical underpinnings of providing flexible learning opportunities to think, feel, and act to elicit meaningful, expert learning opportunities.

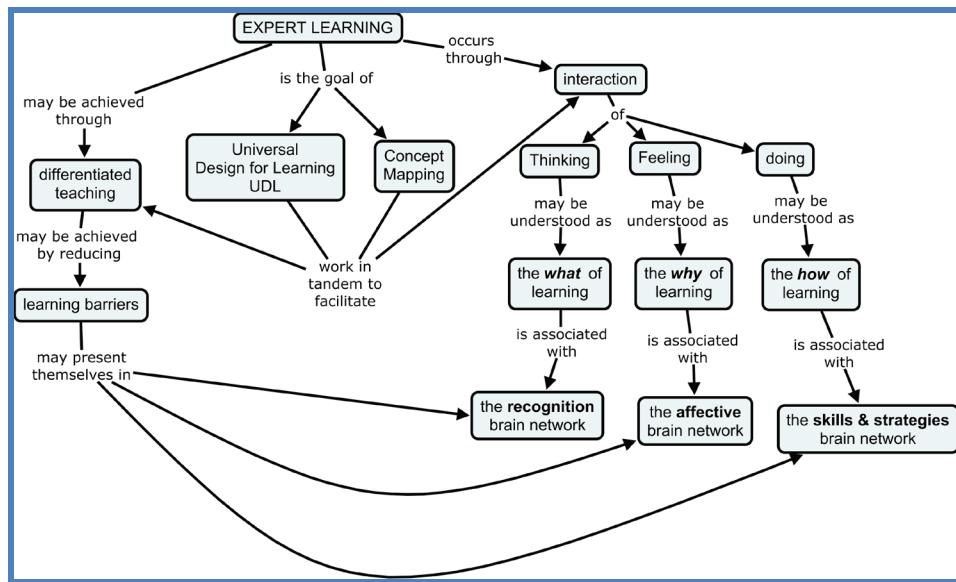


Figure 4: Intersections of Concept Mapping and Universal Design for Learning (UDL)

4 Concept Mapping

Concept Mapping may respond effectively to the development of a learner-centred approach and to teaching and learning which addresses learner variability and individual differences. Across a variety of settings, grade levels and content areas, the use of CMaps in the classroom has shown positive effects on learning (refer to Fig.5-8). This has been revealed in the wide-variety of research studies presented at International Concept Mapping conferences.

A concept map is a type of a node-link diagram that has labeled nodes to represent the concepts or ideas relevant to the topic under study. Links that represent the relationships between the concepts or ideas are included to indicate the nature of the relationship. This node-link-node representation promotes deep learning and challenges surface or superficial learning. Consequently, Concept Maps challenge rote learning, since to create the link between two concepts the learner must have understood the concepts really well. Many learners tend to study by heart chunks of information, without deeply understanding the meaning. Through Concept Mapping learners are encouraged to think reflectively and creatively and to construct their own knowledge in a way that would make sense to them and learning in this way becomes less superficial and more meaningful. Furthermore, knowledge which is learned by rote tends to be forgotten quickly unless it is repeated several times. However, that knowledge which is learned meaningfully, knowledge which is learned in a way which makes sense to the learner, tends to last longer. Learning by heart does not modify or delete faulty ideas but Concept Mapping allows the learner to reflect, evaluate, add, delete or modify the development of new knowledge.

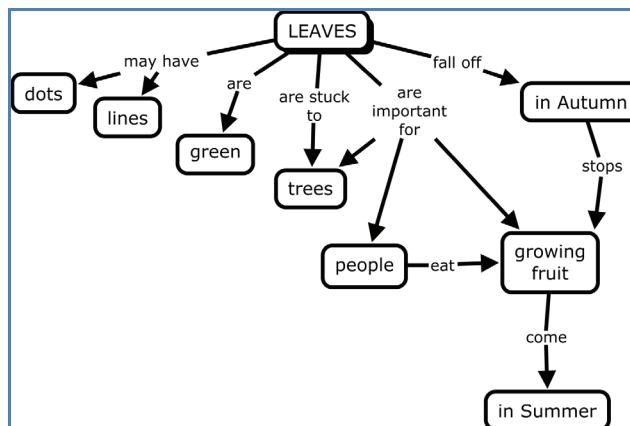


Figure 5: A seven year old First Concept Map before the learning programme.

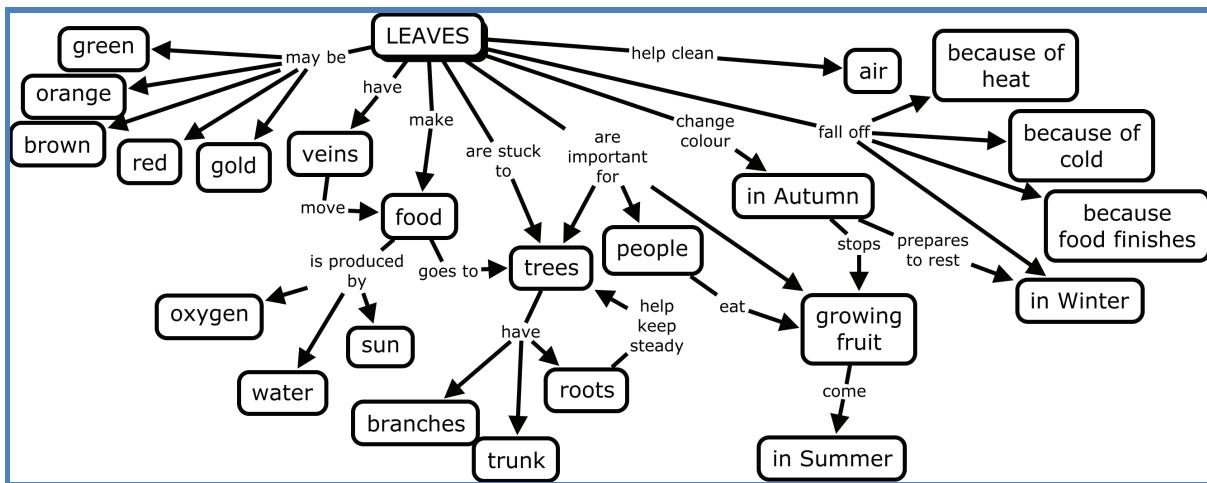


Figure 6: A seven year old Second Concept Map after the learning programme.

Research shows that new meaningful knowledge does not occur in a vacuum and therefore prior knowledge has to be taken into consideration if we expect meaningful learning to take place. One of the values of CMaps is that when learners construct their own Concept Maps for a question or problem in any domain, they visually and clearly convey at a glance what the learner already knows since CMaps give a specific picture of what knowledge the learner has and how this is being developed. As a result the teacher and learner can negotiate and plan together to build upon this. This is referred to in educational psychology as metacognition and scaffolding (better known as Vygotsky's Zone of Proximal Development).

When teachers understand what students think about concepts or events under study, they can be in a much better position to pin-point any invalid ideas or any missing information and they will be able to better formulate lessons and differentiate instruction based on the learners' needs. Vanheer (2008, 2012) reveals that meaningful learning is achieved when learners are given the opportunity to construct a first Concept Map at the beginning of a learning programme to capture prior knowledge and then this is developed into a second Concept Map at the end of the learning programme (refer to Fig 5-8). Similar results were reflected and substantiated by Balgopal and Wallace (2009).

Concept Maps are grounded in theories of how people learn and they have originated from a constructivist perspective theory of learning which holds that learners construct their own knowledge as opposed to the preceding dominant belief of knowledge as something that is acquired through direct transfer and rote learning (Gage & Berliner, 1998; Twomey Fosnot, 2005; von Glaserfeld, 2005). Constructivists suggest that prior knowledge is used as a framework to learn new knowledge. Furthermore, they suggest that how we think influences how and what we learn. Concept Maps identify prior knowledge, the way we think and the way we see relationships in between knowledge.

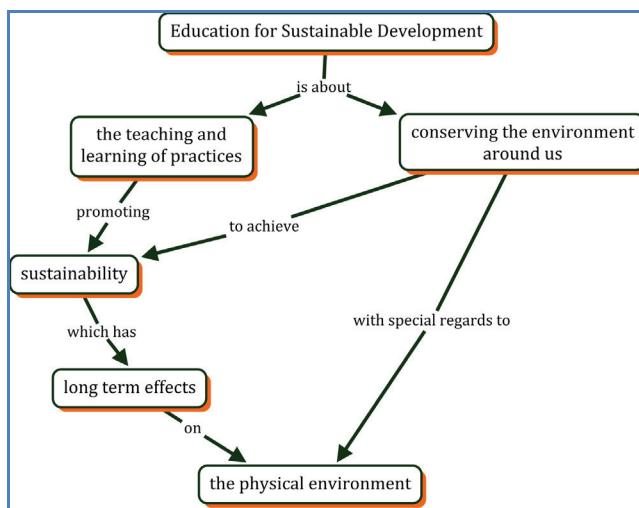


Figure 7: A Higher Education student First Concept Map before the learning programme.

Nonetheless, although CMaps may be seen as an effective cognitive tool, the actual process of constructing a Concept Map involves another mental process which in UDL terminology is referred to as the strategic network. Learners are actively engaged while constructing a Concept Map and they will be creating it at their own pace. The CMapTools software features enhance this brain network by allowing different means of action and expression. This whole process will lend itself to the active participation of the students and will create an environment of learning where understandings are negotiated and knowledge is constructed as opposed to environments where learners are “passive recipients of the wisdom of a single speaker” (Ramsden 2003:108). Engaging the students in active participation increases their motivation to learn and so makes them more likely to learn, retain and process the information presented (Novak & Gowin 1984; Novak, 1998; Booth, 2011). Price & Nelson (2011:70) suggest that “when students are involved in lessons or activities made interactive through the use of active participation strategies, they are also more likely to be attentive, less likely to be off-task, and more likely to feel good about their competence.” This will lead learners to have a sense of positive feeling while constructing their own Concept Map. This will consequently lead to learning enthusiasm, commitment and co-operation. Hays (2006:346) shows that positive emotions enhance motivation and help the learners to focus their attention on learning. Furthermore, “practices that enhance positive emotions, and help the learner perceive the task as interesting and personally relevant help enhance motivation and result in increased effort.” A positive motivation practice improves performance and achievement. This cognitive and affective domain connection was explored through the use of Concept Maps and substantiated by Balgopal and Wallace (2009) in the Environmental Education field to promote ecological literacy.

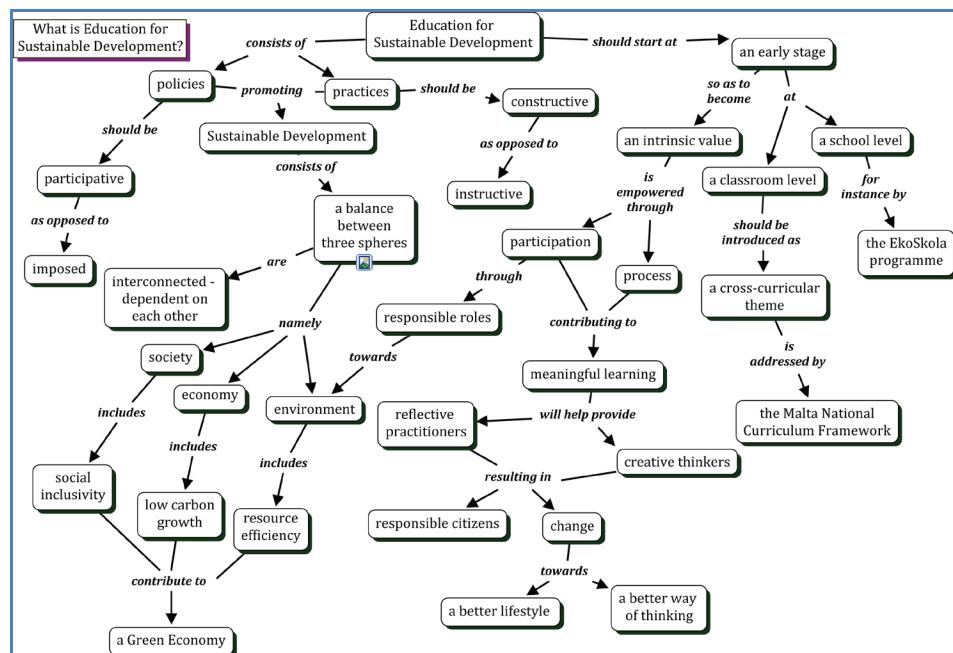


Figure 8: A Higher Education student Second Concept Map after the Learning Programme.

Novak's creation of Concept Maps emerged as a new paradigm in cognitive learning, highlighting the learners' internal mental processes as the major factor in learning. Novak's work has always, since its inception, referred to these mental processes as a complex interplay between **thinking** (cognition), **acting** (conation) and **feeling** (affectation) (Novak & Gowin, 1984; Figure 1). Nonetheless, some authors tend to highlight cognition and to a lesser extent conation at the expense of the importance of the role of affectation in using Concept Maps. The general discussions of results generated by some authors and researchers in the field of the use of Concept Mapping in education focused on concepts and propositions and their development and showed that the uses of Concept Maps reveal personal complex structures of knowledge and how this is integrated and expanded within a learner's cognitive structure. This kind of research presents only results related to cognition and miss out on showing how or what kind of other mental processes were involved in learning thus limiting the potential of the use of Concept Maps.

This may be due to the fact that “*most research in education is method driven rather than theory driven*” (Novak, 2010:20 original emphasis) and as such, researchers using Concept Maps limited their use to what could be measured and as a result overshadowed or devalued the aspects of doing and feelings or emotions. Similarly, various authors in the field argue that attention to cognition and overt behaviours has overshadowed the significance of feelings (James, 2009;Forgas, 2000; Fineman, 1993; Jarvis, 2006).

5 Conclusion

Although “*the person is a complex phenomenon*” (Jarvis, 2006:195) and we do not know enough information to determine causal attributions to learning since “*humanity and the human society are continually developing*” (Jarvis, 2006:200), research in neuroscience is revealing that cognition, affectation and conation cannot be studied as disparate elements, but must analyze systems and networks of connections if one wants to understand how learning occurs and empower meaningful and expert learning experiences. This discussion aims to promote Concept Maps not only as cognitive tools, but tools which also take into consideration other mental processes namely, affective and conative. Similar to UDL’s mission and research base to educate the whole learner, Novak’s theories for learning focus on the process of learning, rather than content acquisition alone. Such theories of learning emerged as paradigm shifts to consider learning as a complex, dynamic system of networks that impact the process of thinking (cognition), acting (conation), and feeling (affectation) (Novak & Gowin, 1984) through the three main neural networks that impact learning in the brain: recognition, strategic and affective (Rose and Meyer, 2002). This perceptual shift in education emphasizes ultimate goals of learning to be directed toward purposeful, meaningful experiences that are guided through expert teaching and learning practice. With process- and theory-focused initiatives, rather than only method driven, the implications of flexible learning opportunities to reduce barriers and account for variability present in learning environments are innumerable. We propose that studies of Concept Mapping as a tool to initiate learning through affective neural networks, as a point of engagement and access to curriculum, be further pursued and better integrated into educational preparation and practice.

“Successful education must focus upon more than the learner’s thinking. Feelings and actions are also important. We must deal with all three forms of learning. These are acquisition of knowledge (cognitive learning), change in emotions or feelings (affective learning) and gain in physical or motor actions or performance (psychomotor learning) that enhance a person’s capacity to make sense out of their experiences. A positive educational experience will enhance a person’s capacity for thinking, feeling and/or acting in subsequent experiences. A maleducative or miseducative experience will diminish this capacity. Humans engage in thinking, feeling and acting, and these combine to form the meaning of experience.”

(Novak, 2010:13)

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CONCEPT MAPPING INFORMED BY COGNITIVE LOAD THEORY: IMPLICATIONS FOR TASKS INVOLVING LEARNER-GENERATED CMAPS

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Abstract. Cognitive load theory (CLT) presents principles that serve as guidelines to improve instructional design. CLT foundations are based on a model of human cognitive architecture that assumes an unlimited long-term memory (LTM) and a limited working memory (WM). This cognitive approach aligns with Ausubel's learning theory but also explains in more detail the role of instructional design (e.g., selection of study materials and organization of the learning tasks) to understand how we construct and automatize schemas. Concept maps (Cmaps) have been widely recognized as a graphical organizer that can foster meaningful learning. However, the cognitive overload caused by tasks involving learner-generated Cmaps has rarely been discussed. Beyond processing the learning content (intrinsic cognitive load) the Cmap elaboration (extraneous cognitive load) must be simultaneously handled by the WM. All this cognitive demand (intrinsic + extraneous cognitive loads) might surpass the learners' WM resources. The cognitive overload caused by the learner-generated Cmap task hinders meaningful learning. This paper brings new theoretical insights from CLT to discuss the critical role of training novice users to fully understand the central concepts of concept mapping (proposition, focus question, recursive revision, and hierarchy). We advocate the need to improve the instructional design of training methods to reduce the extraneous cognitive load caused by learner-generated Cmap tasks, avoiding the cognitive overload. CLT explains why the lack of effective training on concept mapping produces the naïve Cmaps usually obtained in everyday classrooms.

Keywords: Cognitive Load Theory, Cognitive Overload, Concept Mapping, Instructional Design, Training Methods.

1 Concept mapping in everyday classrooms: A closer look at some challenges

Concept maps (Cmaps) are graphic organizers used to represent mappers' knowledge structures. They were first proposed by Novak and colleagues in the 1970s (Novak, 2010). The propositional structure of Cmaps (initial concept – linking phrase → final concept), which asks for the inclusion of linking phrases to clarify conceptual relationships, makes concept mapping more powerful than other graphical techniques used to represent knowledge and information (Correia, 2012; Davies, 2011). The use of Cmaps in everyday classrooms and e-learning environments depends on a sound understanding of the theoretical foundations of this technique. The difficulty of representing mental structures in map-like diagrams (e.g., Cmaps) is frequently overlooked in the literature (Zumbach, 2009). The ease of using programs such as CmapTools is confounded by the demanding task of selecting concepts and propositions to create good Cmaps (Aguiar et al., 2014; Aguiar & Correia, 2013; Cañas et al., 2014; Cañas & Novak, 2006). In other words, concept mapping is a cognitively demanding task to produce a diagram that resembles the mapper's mental structures about a specific learning content.

Research on concept mapping applied to learning suggests that tasks involving learner-generated Cmaps can support meaningful learning based on the following aspects:

- Cmaps encourage students to engage in productive activities fostering active learning (de Jong, 2010; Klahr & Nigam, 2004; Mayer, 2004).
- Cmaps can reflect students' understanding of the learning content (Shavelson et al., 2005).
- Concept mapping promotes deeper information processing during Cmap elaboration (Nesbit & Adesope, 2006).
- Cmaps enable teachers to assess and correct a learner's misconceptions, fostering the pedagogic resonance (Kinchin et al., 2008; Novak, 2002).

The critical condition for achieving these benefits is knowing how to create good Cmaps - namely, Cmaps presenting propositions with clear semantic meanings that reflect the mappers' understanding of the learning content. In other words, the Cmaps (external knowledge representation) must be related to the mappers' mental models (internal knowledge representations).

Some papers in the literature highlight that Cmap construction requires extensive training (Aguiar et al., 2014; Aguiar & Correia, 2013; Conradty & Bogner, 2010; Correia et al., 2008; Hilbert & Renkl, 2008; Karpicke & Blunt, 2011). This is a cognitively demanding process (Hall & Blair, 1993) and requires significant intervention on the part of the instructor to guide novices who struggle with this unfamiliar technique and the

conceptual content to be mapped (Robinson et al., 2003). Moreover, Cmaps are content-specific visualization tools; in other words, it is not possible to learn how to use them without specific content to be mapped. The cognitive load of creating good Cmaps is higher than most teachers can imagine because the student needs to carry out two simultaneous processes:

- Understand and apply the rules of how to make a Cmap; and
- Understand the topic to be mapped to select concepts and propositions to organize the Cmap.

Learning in complex domains such as mathematics, computer programming, and science is typically constrained by the working memory's (WM) limited cognitive processing capacity. For novices, learning tasks in these domains typically represent situations near the limit of their WM resources. The association of content complexity and cognitive processes to solve the task at hand (e.g., mapping the conceptual relationships about a topic under study) can surpass the WM resources and cause cognitive overload. In such a situation, the learning process (construction and automation of new conceptual schemas) is impaired (Sweller et al., 2011). Cognitive load theory (CLT) offers relevant inputs to understand and describe why learner-generated Cmaps might hinder meaningful learning. In other words, we can use CLT theoretical background to set up an explanation about why the lack of effective training on concept mapping produces naïve Cmaps usually obtained in everyday classrooms.

Figure 1 summarizes a cycle of events that occurs in everyday classrooms when Cmaps are used without planning for and understanding of this technique of knowledge representation. Teachers' lack of theoretical background, methodological planning, and practical knowledge in concept mapping can lead to the following undesirable sequence of events.

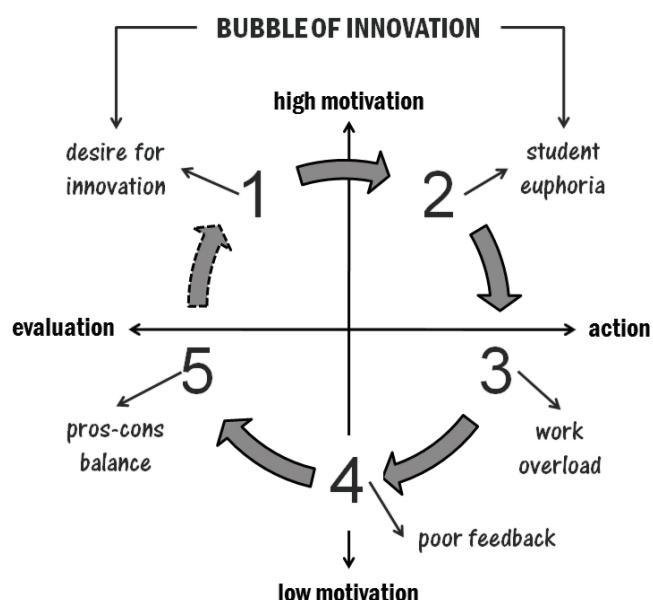


Figure 1. Why are everyday classrooms resistant to change? A five-event cycle describes our hypothesis, considering reflective practice (x-axis) and motivation (y-axis) as the main variables. The “innovation bubble” is an analogy to economic bubbles, characterized by high expectations associated with poor fundamentals to justify them.

- 1) Desire for innovation: the teacher uses Cmaps to change the classroom routine.
- 2) Student euphoria: the students produce many Cmaps in a short period of time (few classes) because they are fascinated with the new classroom climate.
- 3) Work overload: the teacher has difficulty handling the large amount of Cmaps because the textbook does not provide an appropriate grading method.
- 4) Poor feedback: the teacher stops providing feedback to the students creating Cmaps, and evaluation is restricted to a simple verification of their production.
- 5) Pros-cons balance: the teacher does not realize all the benefits of concept mapping, makes unfavorable judgments about it, and avoids future use.

The main goal of this paper is to use the CLT perspective to analyze the learner-generated Cmap process in different situations, considering (i) the level of understanding of the concept mapping technique and (ii) the level of understanding of the topic to be mapped. Our rationale can illuminate some discussions involving the instructional design of concept mapping activities to be adopted in classroom or e-learning environments.

2 New inputs from the cognitive load theory

CLT was initially developed in the 1980s from strictly controlled experimental studies (e.g., Sweller, 1988; Sweller & Cooper, 1985). CLT is concerned with the manner with which cognitive resources are used during learning through problem solving. This theory generates some instructional design principles to optimize the limited WM cognitive resources in order to improve learners' ability to use acquired knowledge and skills in new situations. All these instructional principles are based on the human cognitive architecture and the cognitive load management required to boost the creation and automation of new conceptual schemas.

2.1 Working memory and long-term memory: Different properties and functions

CLT assumes a limited short-term memory (i.e., WM) that can hold no more than five to nine information elements. It is able to deal with this amount of information for no more than a few seconds, and almost all information is lost after about 20 seconds. WM is limited in capacity when dealing with completely new information (i.e., concepts and propositions from a new subject) because, as the number of elements that need to be organized increases linearly, the number of possible combinations of elements that must be tested for effectiveness during problem solving increases exponentially (Sweller et al., 2011).

New concepts and propositions must be chunked and stored in the long-term memory (LTM) to ensure the schema construction and automation. The schema construction can be achieved through the incorporation of new elements in schemas already available in LTM or by obtaining already schematized information from experts. Schemas can then be treated as a single element in WM when they are well-known and automatized, significantly reducing the cognitive load imposed on WM. Constructed schemas can become automated if they are repeatedly applied and yield the desired results. Because automation requires a great deal of practice, well-designed instruction should not only encourage schema construction, but also support schema automation for those aspects that are consistent across tasks (Sweller et al., 2011).

In parallel with Ausubel's assimilation theory (Ausubel, 2000), schema construction refers to the manner of novel information is incorporated in previous cognitive structure and might be held in LTM. Schema automation can be understood as meaningful learning - that is, when learners are able to use relevant knowledge as a single element to solve new problems different than those used during the learning process.

2.2 Cognitive loads imposed on the WM during the learning process

The CLT distinguishes three types of cognitive loads capable of interfering in the WM's processing information and consequently with the learning outcomes (Sweller et al., 2011):

- **Intrinsic load:** refers to the nature, complexity, and difficulty of the content with which learners must deal during the learning task. For example, reading a list of concepts imposes less intrinsic load than reading a Cmap. Whereas the first task involves several single and disconnected elements (low element interactivity), the second task needs to understand the connections among the concepts embedded into a propositional network (high element interactivity).
- **Extraneous load:** refers to the nature of the instructional design used to present the learning material or task. For example, there are several ways to address the meaning of a *square*. One could be to present a verbal or textual description of vertical and horizontal lines that meet in 90° angles. Another way is to present plenty of images of diverse squares and, in the end, a short definition of it. Despite dealing with the same concept, the first instructional option will increase the level of extraneous load and possibly affect the learning process.
- **Germane load:** refers to the WM resources devoted to the schema creation, from the conceptual manipulation of the information presented through the instructional material. During the learning task, students must engage in highly demanding cognitive processes, such as analysis, classification, organization, and inference.

These cognitive loads are different ontological categories related to the learning content (intrinsic), instructional material/task selected by the teacher (extraneous), and cognitive processes used to learn (germane). Intrinsic and extraneous cognitive loads are additive and must be managed to avoid overload. This condition is critical for making WM cognitive resources available to process information and learn (germane). Figure 2 represents how instructional planning can be used to avoid cognitive overload by reducing intrinsic load, extraneous load, or both.

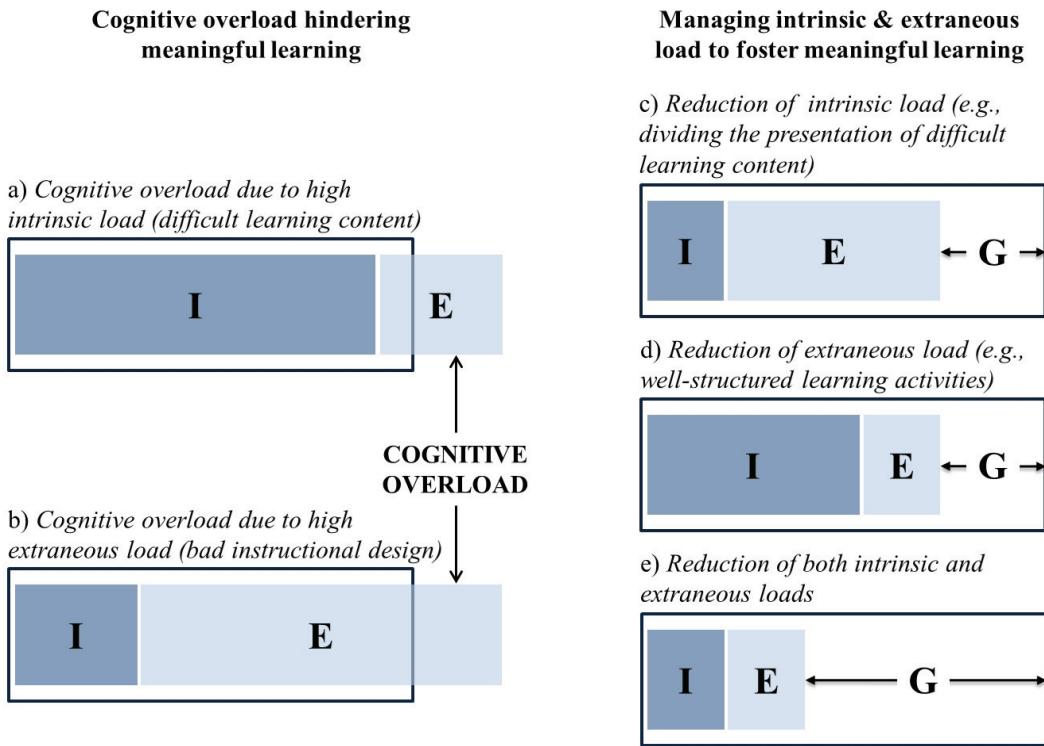


Figure 2. Additive feature of intrinsic (I, blue) and extraneous (E, light blue) loads imposed on the WM cognitive resources (rectangle). Cognitive overload can be reached due to high (a) intrinsic load or (b) extraneous load. The overload condition can be avoided by reducing (c) intrinsic load, (d) extraneous load, or (e) both. Germene load (G) only appears when there is no overload of WM (c–e).

The sum of intrinsic (I) and extraneous (E) loads can surpass the WM cognitive resources (Figure 2a-2b). This cognitive overload hinders meaningful learning because there is no resource available to germane (G) processes (creation and automation of new conceptual schemas) take place. The management of I and E loads is critical for liberating WM resources to G processes (van Merriënboer & Sweller, 2010). We can reduce I, E, and both loads (Figure 2c-2e). The I load cannot be altered by instructional interventions without changing the topic to be learned (e.g., simplification of the learning task by dividing the topic into several classes). Simple contents have low element interactivity requiring less WM resources once the concepts can be learned in isolation (Figure 2c). As a result, fewer WM resources are needed to handle the I load, and G processes can take place during the learning process. This condition is likely to produce meaningful learning.

Figure 2d shows the E load reduction due to a well-planned learning task. Ill-structured instructional designs impose a high E load, especially when learners must use weak problem-solving methods that require them to arbitrarily try out things without being given proper guidance or scaffolding. Learners use the most WM resources to deal with the instructional materials and/or learning tasks. One goal of instructional design is to reduce the E load (Sweller et al., 2011). The selection of instructional materials and the design of the learning tasks are teachers' responsibility, and they can apply any of several principles derived from CLT (van Merriënboer & Sweller, 2010). The reduction of the E load using suitable instructional design can avoid cognitive overload, and G processes can take place during the learning process. This condition is likely to produce meaningful learning. Finally, Figure 2e shows a similar effect when I and E loads are reduced to make WM resources available to G processes.

3 Cognitive loads of tasks involving learner-generated Cmaps

Learner-generated Cmaps are the products of highly cognitive demanding tasks. They can be analyzed considering the loads (I, E, and G) proposed by CLT (Figure 3). Two key variables are used to determine the existence (or not) of cognitive overload: (i) learners' prior knowledge of the content to be mapped and (ii) learners' prior knowledge of the concept mapping technique. These variables affect the I and E loads, respectively, and must be taken into account to avoid WM cognitive overload.

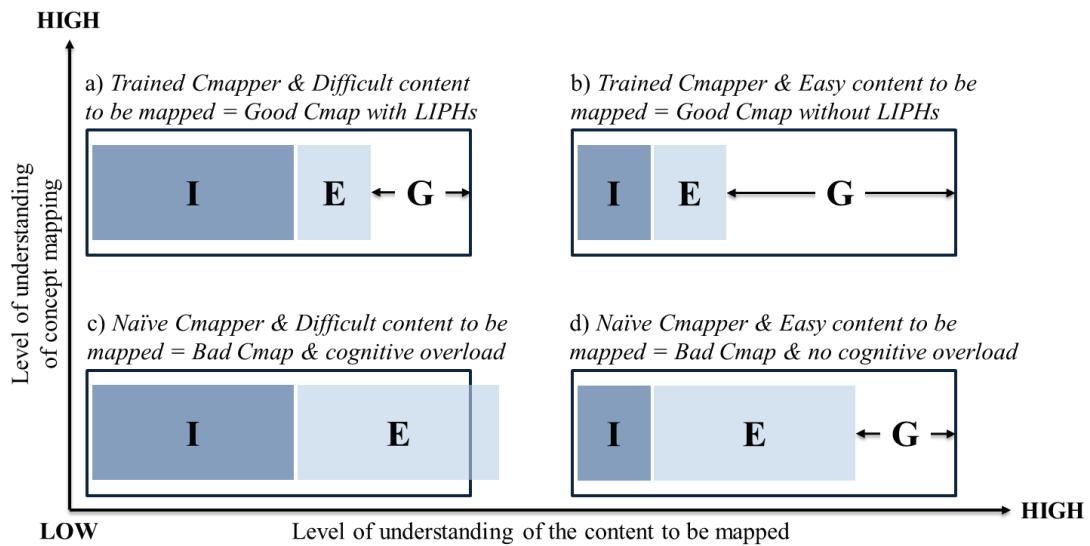


Figure 3. Four conditions considering the analysis of learner-generated Cmap tasks using the learners' level of understanding of the content to be mapped (I, x-axis) and the concept mapping technique (E, y-axis). Trained Cmappers are likely to produce good Cmaps (a–b) whereas naïve Cmappers are likely to produce bad Cmaps (c–d), even when there is no cognitive overload (d).

Training learners to become skilled Cmappers reduces the E load (Figure 3a-3b) because the ability to make Cmaps is directly related to the design of the learning task. In this case, learners can always produce good Cmaps related to their knowledge. Cmaps about difficult topics (Figure 3a) might present some errors or conceptual limitations. As Novak suggested, meaningful learning can be fostered from the limited or inappropriate propositional hierarchies (LIPHS) that allow teachers to provide precise feedback considering the specific conceptual gaps revealed in the Cmaps (Novak, 2002). On the other hand, Cmaps about easy topics (Figure 3b) are likely to be good without LIPHS.

Naïve Cmappers who do not receive training on how to create good Cmaps face a higher E load (Figure 3c-3d). They do not know how to produce good Cmaps, and the outcome is likely to be bad Cmaps with no or unclear propositions. Bad Cmaps do not reveal the mappers' knowledge structure appropriately and are not related with the internal knowledge representation (mental models). Bad Cmaps are obtained for both difficult (Figure 3c) and easy (Figure 3d) topics. Even knowing the content (easy topic), naïve Cmappers cannot express their understanding through concept mapping; in such cases, it is better to ask them to write a text to assess their knowledge of the content to be learned. No cognitive overload occurs in this condition (Figure 3d), and the level of understanding of concept mapping is the unique variable that hinders the creation of good Cmaps. The critical role of training novice users using a well-designed set of activities becomes clear with this rationale, which is why our research group devoted time and resources to developing a set of strategies to improve the skills of students on concept mapping (Aguilar et al., 2014; Aguilar & Correia, 2013; Correia et al., 2008). We argue that more than a few minutes is needed to train students appropriately to become good Cmappers.

Cognitive overload appears only when naïve Cmappers need to map a difficult topic (Figure 3c). We believe this condition might represent the use of concept mapping in many everyday classrooms. The poor training of students is associated with ill-structured activities involving Cmaps. This combination helps explain the innovation bubble presented in Figure 1. Students are stuck in a context that does not allow for the creation of good Cmaps. Therefore, the expected benefits related to fostering meaningful learning will not be achieved. Teachers and students will make unfavorable judgments about concept mapping and will abandon the use of Cmaps. In sum, naïve mappers (Figures 3c-3d) can explain why we obtain bad Cmaps in many activities we develop in everyday classrooms. Thus, the critical role of training students to become trained Cmappers is highlighted once again.

4 How to design a task involving learner-generated Cmaps

The task for the elaboration of Cmaps impacts their content and structure. Cañas et al. (2012) highlighted this effect of task configuration on students' Cmaps using a graph to organize typical Cmap tasks into a continuum from total freedom to total restriction of content and structure (Figure 4). This approach provides an insightful connection between instructional design and learning outcomes (students' Cmaps).

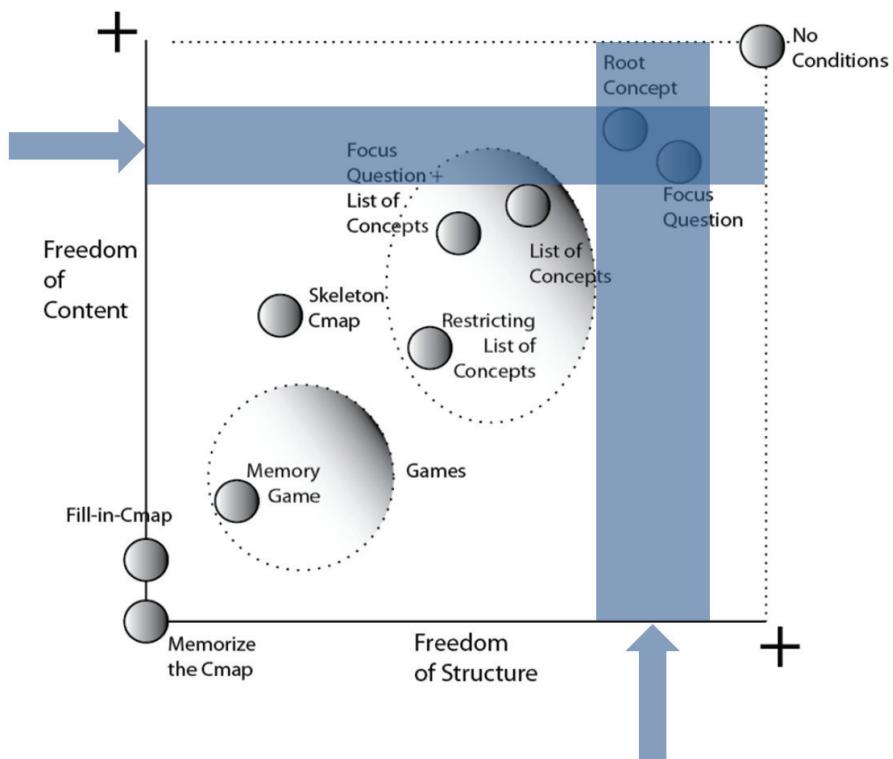


Figure 4. Freedom of structure and content conditions to describe concept mapping task. The instruction to elaborate Cmaps can vary from total freedom (no conditions) to total restriction (memorize the Cmap), which affects students' Cmap (Cañas et al., 2012). Blue columns highlight our preferred option to set up a task involving learner-generated Cmaps. The E load is reduced when a root concept and a focus question are provided.

The maximum degree of freedom (no conditions) is more appropriate for experts in concept mapping and the topic to be mapped. They can use WM resources to model their knowledge using Cmaps because they do not need to create and automatize conceptual schemas. Experts already have these schemas and are easily manipulated in WM (these chunks of information impose low cognitive loads). On the other hand, trained Cmappers who are learning about a topic can face a high E load when facing too much freedom. Despite knowing how to use the concept mapping technique, they need to deal with content that is not in well-organized conceptual schemas. The I load is high in this situation, and we need to design a task involving learner-generated Cmaps that lower the E load. Providing a root concept and a focus question are two strategies our research group usually adopts to (i) get a set of comparable Cmaps and (ii) reduce the E load of the task. This information calls students' attention to key parts of the topic under study and activates their knowledge while considering these cues. The cognitive effort to make a Cmap in this condition is mainly related to the I load and G processes to manipulate the conceptual schemas they already have. Frequently produced Cmaps reveal learners' LIPHS; in this condition, concept mapping can be more valuable in everyday classrooms. Pedagogic resonance is possible, and the collaboration between teachers and students can happen in favorable conditions because learners' knowledge is visible (Kinchin et al., 2008). Teachers can provide specific and powerful feedback to remediate misconceptions and foster meaningful learning during their courses.

5 Acknowledgements

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CONCEPT MAPPING USING NOVAK'S AND TROCHIM'S APPROACHES:CLASH OF THE TITANS OR A MARRIAGE MADE IN HEAVEN?

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Abstract: This paper presents the early results from an empirical study that has used a combination of two concept mapping methodologies, those of Novak (1990) and Trochim (1989), to explore students' understanding of Mental Health Nursing whilst on a three-year undergraduate training course. The paper will first explore each approach and then compare how the two concept mapping methodologies differ. The paper outlines how this study has integrated the two approaches into a single methodology. The findings of this study suggest that each of the approaches lead to different yet complimentary results. This indicates that each approach adds a different level of comprehension to the overall findings. The paper will discuss the strengths and limitations of this integrated concept mapping approach and make suggestions for further improvements.

Keywords: Concept mapping, methodology, professional education, mixed methods.

1. Introduction

The term 'concept mapping' is used to describe any methodology that is used to produce a pictorial representation of an idea (Trochim & Kane, 2005). Concept maps depict participants' understandings of the importance and the relationship between different concepts (Hammersley, 1996). Two clear approaches to concept mapping have emerged that are distinct and different. The aim of this paper is to explore the use of two approaches to concept mapping to explore a single topic: Mental Health Nursing.

The first concept mapping approach used was outlined by Joseph Novak (1990). This approach provides guidelines for the participants to develop their own individual map of a given topic. Novak's approach is based upon Ausubel's learning theory (1963), which postulates that learning occurs when new information is assimilated into existing knowledge structures. Hay (2007) used concept mapping to categorise deep learning, surface learning and non-learning in students based upon how individual's knowledge structure changes over time. This approach has been used in a wide range of disciplines to examine personal learning trajectories.

The second concept mapping approach was developed by William Trochim (1989). This approach asks participants to generate meaning statements about the given question or topic. These statements are collated for different participants into a single group of statements. These statements are then ranked according to their relative importance and clustered into themes defined by the participants. This approach then analyses this data using a statistical process called agglomerative cluster analysis, which leads to formation of the concept map (Trochim, 1989). This concept mapping approach too has been used to explore a range of topics.

Table 1, below, summarises the differences between Novak's and Trochim's concept mapping methodologies.

Table 1: Comparison of Novak's and Trochim's approaching to concept mapping methodologies

	Novak's Concept Mapping	Trochim's Concept Mapping
Focus	Individual	Group
Research paradigm	Qualitative	Quantitative
The concept map is....	The start of the process	The end of the process
Theoretical underpinnings	Learning theory (Ausubel, 1963)	Systems theory (Veney & Kaluzny, 1984)

This paper focuses on the analysis at a group level. A separate paper, *Becoming a Mental Health Nurse: A three year longitudinal study* (Wells & Bressington, submitted) provides a more detailed Novakian analysis of the individual maps.

2. Method

2.1 Participants

This study used a convenience sample of students ($n=60$) recruited from the two undergraduate pre-registration programmes in Mental Health Nursing. One university is located in London, UK and the other in the South East of the UK. All students on the first year of the programme were eligible to participate. The data was collected as part of their education programme to encourage critical reflection of what it means to be training as a mental health nurse. Permission to use the data for research purposes was formally requested from potential participants and ethical approval was granted by the Faculty research ethics committee.

2.2 Procedure

The procedure used in this study is outlined below in figure 1.

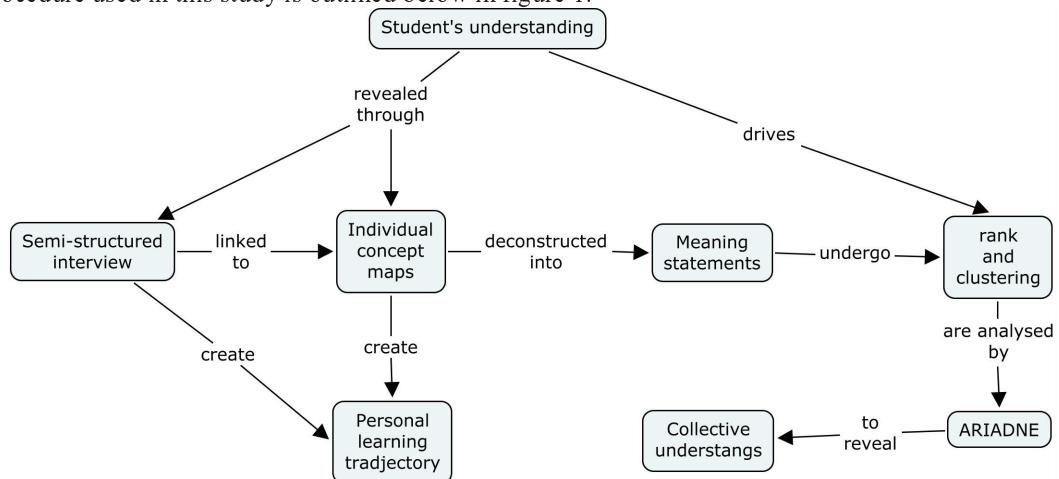


Figure 1: A concept map of the methodology used in this study

The individual concept maps were created using Novak's approach to elicit participants' understanding of 'Mental Health Nursing' (Novak, 1998). Maps were created at the beginning, middle and end of each year of the programme, totalling nine data points. Next, the concept maps underwent a cross-sectional analysis as outlined by Trochim (1989): Each map was deconstructed into meaning statements comprising of concept-label-concept. The statements from all the participants were collated together. Statements that were not clear or did not make sense were rejected. The remaining statements were grouped thematically and the researchers selected the 50 most commonly used statements. These statements were returned to the participants to be ranked on a Likert scale for relative importance and clustered into groups according to the participants' interpretation of the data. The data was then analysed using ARIADNE concept mapping software (Severens, 1995). The output of this analysis is a set of non-overlapping clusters representing themes that are collectively important to the cohort at that moment in the training.

3. Results

This study only considers the data from the first and final maps in order to evaluate the effectiveness of a concept mapping process integrates Novak's and Trochim's approaches. This next section will outline each of the results independently.

3.1 Novakian analysis

A Novakian analysis of the data constitutes an overview of the participants' choice of concepts on their first and final maps. It is appreciated that this is a crude interpretation of Novak's approach to analysis. A more detailed analysis of the participants' maps can be found in a separate paper, *Becoming a Mental Health Nurse: A three year longitudinal study* (Wells & Bressington, submitted).

411 meaning statements were generated by participants in the first maps. The final maps produced 162 statements. Despite the reduction in overall number of meaning statements, there was much greater convergence in the concepts used between the first and last maps. This can be seen on Table 2, below.

Table 2: Ranking the frequency of concepts for first and final maps

First maps			Final Maps	
Concept	Freq.	Order	Concept	Freq.
Patient, client, person	9	1	Person Centred	20
Medication	6	2	Recovery	18
Hospital	5	3	Talking therapy	15
Community	5	4	Medication	15
Communication skills	4	5	Risks	11
Reflection	2	6	Collaboration	9

The frequency of particular concepts changed from the first to final map. In the first map, ‘patient, client or person’ appeared most frequently, followed by ‘medication’, ‘hospital’ and ‘community’. In the final maps, ‘person centred’ appeared most frequently, followed by ‘recovery’, ‘talking therapy’ and ‘medication’.

3.2 Trochimian analysis

The Trochimian concept maps can be seen below.

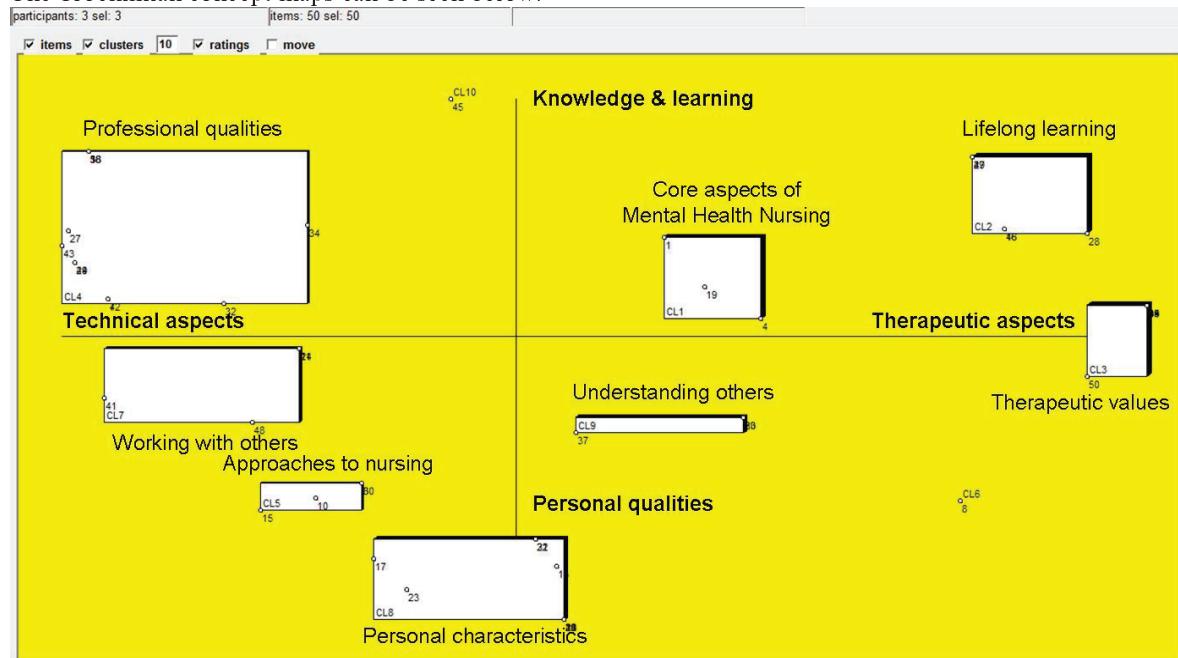


Figure 2: Ariadne cluster analysis of first maps.

The cluster analysis of the first maps shows 8 themes: ‘Core aspects on MHN’, ‘lifelong learning’, ‘therapeutic values’, ‘professional qualities’, ‘approaches to nursing’, ‘working with others’, ‘personal characteristics’ and ‘understanding others’. These are organised on two axes: ‘knowledge & learning’ to ‘personal qualities’, and ‘technical aspects’ to ‘therapeutic aspects’.

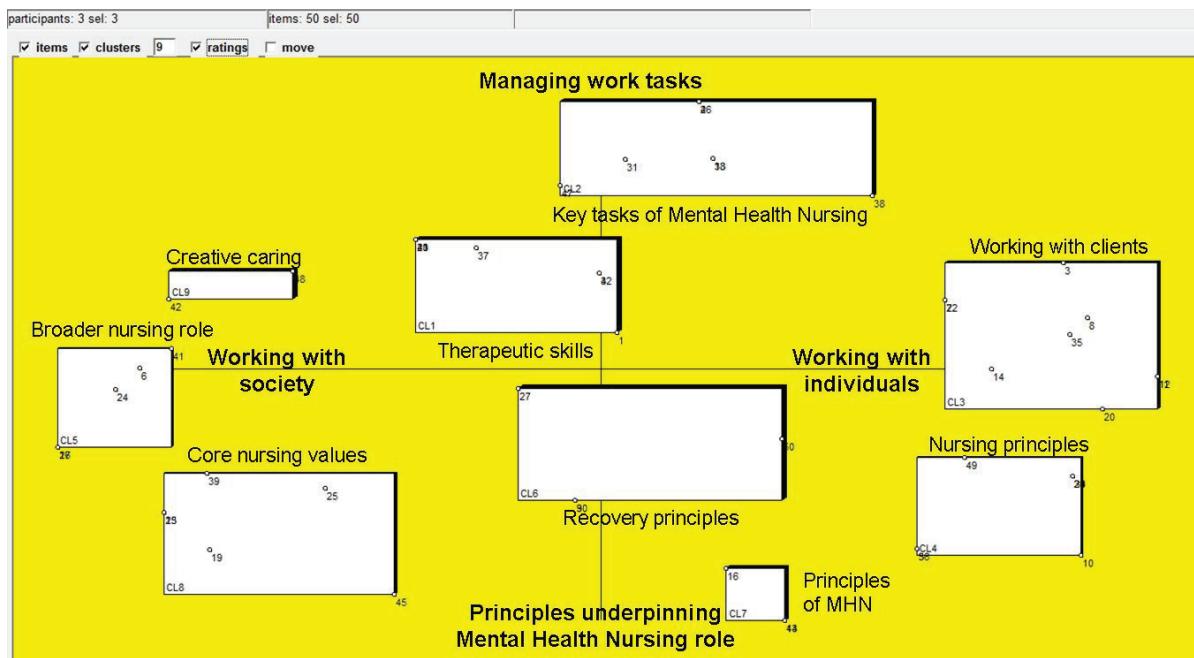


Figure 3: Ariadne cluster analysis of final maps.

The cluster analysis of the final maps shows 9 themes: ‘Therapeutic skills’, ‘key tasks of MHN’, ‘working with clients’, ‘nursing principles’, ‘broader nursing role’, ‘recovery principles’, ‘principles of MHN’, ‘core nursing values’ and ‘creative caring’. These themes are organised on two axes: ‘Managing the tasks of MHN’ to the ‘principles underpinning MHN’, and ‘working with society’ to ‘working with individuals’.

The cluster analysis (Table 3) shows that the highest ranked themes were, for the first map: ‘therapeutic values’, ‘lifelong learning’, and ‘core aspects’, and for the final map to ‘recovery principles’, ‘creative caring’ and ‘therapeutic skills’.

Table 3: Comparison of participants’ ranking of themes for first and final maps

First maps			Final Maps	
Theme	Pref.	Order	Theme	Pref.
Therapeutic values	3.83	1	Recovery principles	3.83
Lifelong learning	3.61	2	Creative approaches	3.5
Core aspects of MHN	3.44	3	Therapeutic skills	3.33
Personal qualities	3.27	4	Principles of MHN	3.11
Understanding others	3.22	5	Key tasks of MHN	3.09
Working with others	2.75	6	Working with clients	3.0
Ways of working	2.5	7	Core values of nursing	2.66
Professional qualities	2.31	8	Broader nursing role	2.6
-	-	9	Nursing principles	2.47

The focus of understanding shifts from ‘therapeutic values’/‘lifelong learning’/‘core aspects’ in the first map to ‘recovery principles’/‘creative caring’ and ‘therapeutic skills’ in the final map.

4. Discussion

The students engaged well with the cyclical nature of the study. They used the development of their own map to reflect on their understanding of Mental Health Nursing. This was an activity that was largely personal and independent from the rest of the group. Conversely, the ranking and clustering tasks were completed in groups. These sessions would frequently be a lively discussion on the relative importance of each of the meaning statements. Each group would typically discuss one statement in some depth before reaching agreement. These sessions encouraged the students to engage with some of the tensions inherent to Mental Health Nursing and to draw their own conclusions about these.

The overall reduction in the number of meaning statements can be partially accounted for by attrition from the programme and therefore withdrawal from the study. However, this does not account for the overall

reduction in meaning statements. Some of this may have been due to the cyclical data collection and clustering-ranking tasks - participants shared their ideas with each other and then ranked and clustered these - which may have led to a shared understanding. However, it is more likely that this convergence is a product of the socialisation into the profession as a product of their education and clinical experiences.

Participants' use of concepts moved away from describing the focus and context of Mental Health Nursing in the first maps to citing the underlying principles of nursing and the key interventions. This suggests that participants' understanding of Mental Health Nursing developed and matured over the course of their training. This conclusion is also supported by the Trochimian analysis, but through different means.

The cluster analysis illustrates that the first maps were aspirational in nature, perhaps identifying the kind of Mental Health Nurse they wanted to become at the end of the training. This had progressed to reveal a much greater awareness of the actual role of the Mental Health Nurse. Equally, the early emphasis on education and their personal qualities decreased from the first map to a greater emphasis on the skills and principles required to support recovery. It may be that the participants felt more equipped to deliver interventions at the end of the programme as they are readied to formally enter the profession.

5. Limitations

This is the first time (to our knowledge) that these two approaches have been used in the same study. This has presented a number of challenges in the process of completing this research. Integrating the two approaches may have sacrificed the purity of doing each separately. The analysis of the results from each approach has been complicated by the combined approach and cyclical nature of data collection, may have influenced the interpretations. The researchers are also tutors on the nursing programmes and this may have influenced both the students' responses and the interpretation of the findings. An attempt to manage this was achieved by each researcher leading the study in the other's university.

6. Conclusion

Each of the two concept mapping approaches used in this study reveals something different. Novak's approach, by proving a framework for the externalising the participant's knowledge structure, allow this structure to be interrogated and discussed. Over time these maps can form milestones along a personal learning trajectory, which can be analysed according to the gross typology. Trochim's approach allows for the analysis of the group's perspective on the important aspects and the relationships between these. This approach allows for a meta-level understanding of how different groups understand a given topic, but is distanced from each individual's understanding. When integrated, these two approaches provide different but complimentary insights into the phenomenon being investigated.

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CONCEPT MAPPING, EVOLUTIONARY BIOLOGY AND READING: A TRANSDISCIPLINARY APPROACH

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Abstract. In order for effective learning to take place, a favorable environment is crucial. A great deal of such environment can be built through the use of specific tools and approaches. In this study we have concentrated our efforts on the learning-teaching of concept maps and reading techniques transdisciplinarily to improve graduate students' understanding on Evolution Biology. For such, two Biology teachers and one Portuguese language teacher developed a 15-hour workshop at a research center in Belo Horizonte, Brazil. The three teachers worked simultaneously during the entire workshop. During this period the students worked on concept mapping construction, from loose concepts on slips of paper to complex concept mapping on complex texts on Evolutionary Biology. This article shows the students' progressive understanding of relevant concepts on Evolutionary Biology through concept mapping and reading strategies. The results that arose from the analyses of the maps and the field notes show that there was a significant improvement on concept mapping, reading and consequently on the understanding of important concepts on Evolution Biology issues discussed during the week. The results also show that the constant interaction during the workshop was of great importance to the students' overall development. At the same time, results suggest that there should be a more systematic and continuous work on transdisciplinarity and concept mapping in educational institutions so that it would be embedded on their syllabus.

Keywords: Concept Map, Evolutionary Biology, reading, transdisciplinarity, higher education

1 Introduction

The application of Concept Maps has been widely used in the educational field. Within this context, there are studies that correlate many areas of knowledge. In the Science Teaching field, there are studies correlating concept mapping with Science Teaching or Evolutionary Biology (Beeson, V. & Culp, T.; Germann, P., Young-soo, K., Patton, M.D., 2001) and with Higher Education (Hay, D., Kinchin, I., Lygo-Baker, S.). Other studies correlate concept mapping with reading (Freire, ABMS, 2005; Freire, ABMS; Freire, ASF, Gregório, R., 2006) and concept mapping and pedagogical practice (Freire, ABMS & Freire, ASF, 2010). It is of no doubt that all these studies are of great relevance in the field of Concept Map as a tool or a strategy for meaningful learning. Such studies show that more attention is being paid to the efficacy of Concept Maps as well as to the crucial need to think and learn meaningfully. However, there seem to be no study comprehending the three areas altogether on Higher Education: concept mapping, Evolutionary Biology and reading.

This study focuses on the teaching-learning of Evolutionary Biology for Higher Education students using concept mapping and reading strategies. The aim of our investigation was to enhance meaningful learning in Evolutionary Biology through Concept Maps and reading strategies.

2 Methodology

An initiative is now under way to develop methods to aid the user during concept map construction. These aids are designed in response to observations of snags which may arise during concept mapping. During concept mapping, users often stop and wonder what other concepts they should add to the concept map they are working on, frequently spending time looking for the right word to use in a concept or linking phrase; they search for other concept maps that may be relevant to the one they are constructing, and they search through the Web looking for additional material that could help them enhance their maps. The following sections describe three methods developed to address these issues.

2.1 Theoretical Framework

The theoretical framework for this study was transdisciplinarity and socio-interacionism, together with reading comprehension strategies, such as pre-reading, reading, keyword recognition and contextual inference (Grellet, 1981).

The perspective of language, specifically of reading as a social practice is present in the studies of Bakhtin (1986), Koch (2003; 2006) and Matencio (2002): the text does not have meaning in itself but in the reader's interaction with the text and with the environment "the student must be an active participant of this interaction, grounding themselves on text cues as well as in their vision of the world." (Matencio, 2002, p.41). Reading is a social practice and the meaning of is, therefore, a social construction. (Koch, I.V., 2003, p.30).

The concept of sharing meaning is also present in concept mapping: "When concept mapping is done in groups of two or three students, it can serve as a useful social function and also lead to lively classroom discussion." (Novak, 1994, p.20). Such view corroborates with Vygotsky's social-interacionist perspective of learning: knowledge implies on shared information among peers and that learning happens more effectively with the help of others. Based on this perspective, a great deal of students' concept maps were made in groups, thus enhancing interaction.

The workshop was also designed to be transdisciplinary: the three teachers worked simultaneously inside the classroom in order to integrate Biology and reading comprehension, thus promoting decompartmentalization of knowledge (Freire, A.B.M.S., 2005). During the whole workshop these two areas(Biology and reading coexisted and interacted dynamically with a common goal (Moita Lopes; Celani, M.A.A., 1998). Such procedure corroborates also with Morin's (2007) definition of transdisciplinarity. According to the author, "transdisciplinarity surpasses the particularity, conjugates knowledge and makes it such that different means work for the same purpose." (Audy J. L. N., Morosini M. C. (Orgs.), 2007, p.30).

2.2 *The Workshop*

The workshop lasted 15 hours, distributed within five days in a roll. In general, the time was distributed as follows: reading, concept mapping, and discussion of the texts. There was a discussion about the texts after each reading. As said in 2.1, most of the times students worked in groups. The groups were constantly rearranged to enhance interaction.

The workshop was divided into four phases, with a progressive increase in difficulty. On phase one, we used sets of loose concepts, written on slips of paper. Each set was about a specific topic, such as "school subjects" and "Olympic Games". In groups, students should make a concept map using the loose concepts on a card paper and present the map to the class. There was a debriefing (discussion) after each presentation about the arrangement of the maps. After the discussion, students were presented to theory about concept maps and about the biological foundations of learning.

On the following phases students worked with texts, arranged according to two aspects: readability and content. Each aspect obeyed different evaluation criteria. To evaluate readability we used the Flesch score. The content analysis was made by the Biology teachers based on the content complexity of the texts given.

On phase two each group received simple texts – Flesch average level = 60 (easy) and content complexity = 0.5 (very easy) – and the corresponding average complexity partially completed map. They should read the texts and fill in the maps. On phase three the texts on Evolutionary Biology, thus were more complex and more specific, with Flesch average level = 43 (difficult) and average complexity = 1.13. On phase four the texts were also about Evolutionary Biology and had a higher level of complexity (Flesch score = 31 (difficult) and average complexity = 1.42. On this phase students built free maps exclusively: one map in group and then two individual maps.

Table 1 shows the Flesch score. Table 2 shows the content complexity averages of the text used.

Table 1: Flesh score. Source: Silva, C.A.T., 2009

Flesch score	Legibility	Instruction level
100 - 75	Very easy	Elementary
74 - 50	Easy	Junior High
49 - 25	Difficult	High School and graduation
24 - 0	Very difficult	Academic texts

Table 2: Biology teachers' texts score pattern based on content complexity

EASY	AVERAGE COMPLEXITY	DIFFICULT
0.0 A 0.59	0.6 A 1,59	1.6 A 2.0

Figure 1 shows a concept map of the workshop methodology

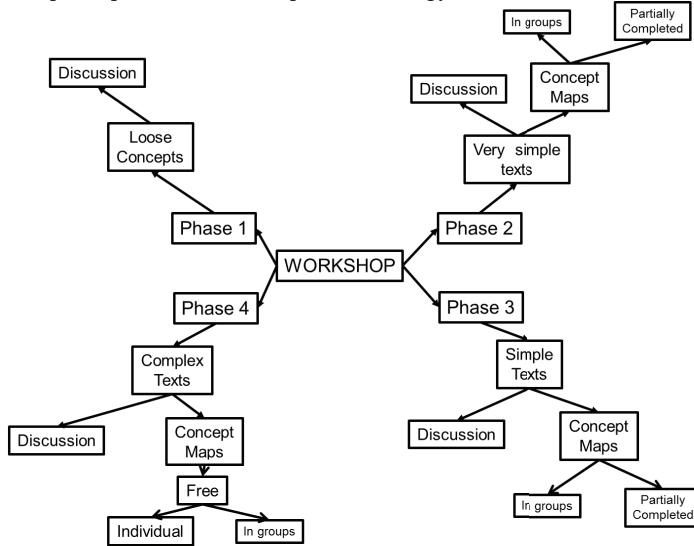


Figure 1: workshop methodology concept map

2.3 Context, Field Participants and Material

The study was designed as a workshop, which took place in the last week of January, 2014 at René Rachou Research Center (CPQRR), in Belo Horizonte, the state of Minas Gerais, Brazil. It was designed mainly for Biology students of this institution. The participation was free of charge and limited to a number of 30 participants. The two main criteria for enrollment were to be a Biology student at the CPQRR and to be working on a line of research. The teachers were from different institutions: CPQRR, UERJ (University of the State of Rio de Janeiro) and CBPF (Brazilian Center of Physics Research) Physics and Humanities Group.

The data used in this study were: photographs, field notes and the students' concept maps.

Field notes have been taken during all the discussion after concept maps construction as said in workshop description. Such notes had been used together with the concept map to register participants impression about the learning process itself, the students' progress and indicate when there are some conceptual changes.

2.4 Concept Maps Analyses

Teachers had read the texts and had made the correspondent concept maps. Such maps have been used as reference to students' maps analyses. To evaluate the maps there were taken some criteria were taken into consideration such as capacity of concept hierarchization, identify important concepts and map spatial organization.

Concept maps analyses began establishing the relation between the rising difficulty of the texts and students performance in concept mapping. In order to establish this relationship we used Pearson correlation and Flesch index described as follows.

2.4.1 Pearson Correlation

The Pearson linear correlation is used to indicate the intensity of a linear correlation between two sets of data. In other words, it is a statistical approach that allows us to observe if the "increase or decrease of a variable X have the same impact in the variable Y" (Figueiredo-Filho e Silva-Júnior, 2009). The Pearson correlation index "r" is calculated as follows:

$$r = \frac{1}{n-1} \sum \left(\frac{x_i - \bar{X}}{s_x} \right) \left(\frac{y_i - \bar{Y}}{s_y} \right)$$

Depending on the result of "r", the correlation vary from perfect positive ($r= 1$) to perfect negative ($r= -1$). If $r=0$, it implies on the absence of linear interdependence. But there can be another non-linear dependence, and $r=0$ must be investigated by other means.

Pearson correlation has been used to establish the relationship between the difficulty in reading comprehension and students' performances. By using this tool we aimed to investigate if students' mistakes would raise proportionally to the complexity of texts.

2.4.2 Flesch Score

Table 3 shows the Flesch score average and the content complexity of the texts given. Flesch method is used to classify the legibility of a text in a scale that goes from zero (difficult) to 100 (very easy).

Table 3: written material and corresponding Flesch score and the content complexity averages

	Material	Flesch score average	Content complexity average
PHASE 1	Loose concepts	-----	-----
PHASE 2	Very simple texts	60	0.5
PHASE 3	Simple texts	43	1.13
PHASE 4	Complex texts	31	1.42

3 Results and Discussion

First of all, we can highlight that the fact that the workshop was transdisciplinary based was essential to the interaction of the group, as many of the students didn't know each other. It was also a great opportunity to discuss about their own learning process. In other words, they could participate actively in the proposed activities. The transdisciplinarity was also an overall gain in terms of discussion about the Evolutionary Biology concepts themselves as well as the concept mapping construction. We could discuss the presented issues more dynamically. Working transdisciplinarily also provided more dynamic classes and, consequently, more interaction.

Secondly, groupwork stimulated their participation in the activities. The students gradually felt more self-confident and independent. From the arrangement of the chairs to the constant rearrangement of the groups, every activity seemed to have helped them socializing with their college mates, creating a pleasant atmosphere.

Thirdly, working with reading strategies and with a socio-interactionist view of the process of reading empowered the students in the sense that they have power over what they read, and that texts are not a bucket of meaning. If meaning is constructed through interaction, therefore we can discuss, agree, and disagree with what we read. This empowerment leads naturally to critical reading, a fundamental characteristic in the academic world.

Concept Maps also provided an effective way of understanding the text, no matter its complexity. It can be perceived on the results of the last concept mapping: even the corresponding text having a Flesch score of 33 (very difficult) and a complexity score of 1.75 (difficult), students' concept maps were more complete and better organized than any of the previous individual maps.

The results are presented as follows: a correlation table, a figure showing students' improvement on concept mapping, and sketches of some students' concept maps.

Table 4 shows the Pearson correlation between the level of difficulty of the texts used (Flesch score) and the average of students' right concepts of their maps during the workshop.

Table 4: Pearson correlation between the right concepts present on students' maps and the Flesch score: R=0,7963.

Flesch Score	Right concept
59	0,78
60	0,83
59	0,63
62	0,54
42	0,53
41	0,63
46	0,45
43	0,27
33	0,39
28	0,11
33	0,30

The R=0,7963 indicates a strong relation between the decrease in the Flesch score (therefore, an increase in the difficulty of the texts) and the attainment score of the concept maps: the difficulty of the maps construction is proportional do the difficulty of the texts.

The first free map was made in group. In this activity students had to deal with the challenge of build the map itself, as it was the first time they were building a map with no help concerning structure or hints of concepts. As to the second and the third last maps, students had to deal with two difficulties: to build them alone and with no structural of concept hints. Naturally, the performance decreased on the second free map, which corroborates to Vygotsky's theory of the most developed pair. But Vygotsky also point out that, if a student can reach a higher level of comprehension with their peers, they are prepared to reach it alone. And that is what is shown on the discussion of the last text, reflected on their last map: the right concepts average triplicates in comparison to the previous map. The maps also show a clearer and more accurate hierarchy. Such improvement can be translated as a gain in autonomy and also a better texts comprehension, which is, then, seen in their improvement in concept mapping during the workshop.

The field notes from Jan.30 and Jan.31 show that students are more participative during the discussions and signalize the attainment of new concepts as well.

Next, figure 2 shows how students improved their concept mapping by the end of the workshop.

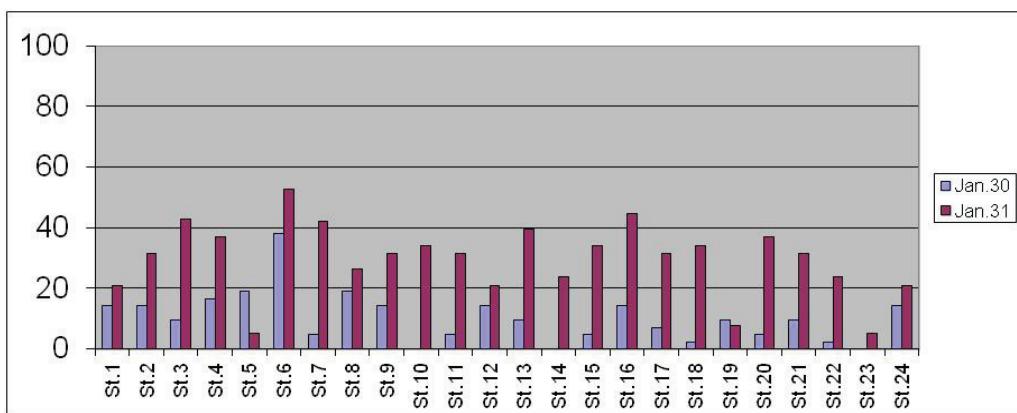


Figure 2: students' maps concept attainment score on phase four (%)

Figure 2 shows the progress of the students' individual maps. The maps made on January 30th show that students could hardly get the main ideas of the text. Based on the score and considering that concept maps reflect their comprehension of the texts, students could not understand 20% of the first text. On the other hand, their students' maps on January 31st show a considerable improvement. Among the 24 students assessed, 19 improved significantly.

Students' improvement on reading was quantitative as well as qualitative. This can be noticed on their individual free maps. Apart from the number of concepts in the maps, the hierarchical organization also improved. Figures 2, 3 and 4 show this improvement.

Apart from the analysis of phase 4, an overall improvement can be noticed: the analysis of the Pearson correlation between the increase of text difficulty and the students' difficulty in building the concept maps. As said in the methodology, the strong Pearson correlation ($R=0,7963$) shows the proportional relation between the difficulty in reading the text with the difficulty in building the maps. But, despite this difficulty, students' comments during the discussions made themselves clear in relation to their gradual progress.

The comparison of the first and the second individual free maps reveal that students managed to improve substantially in concept map construction. Such improvement can be seen in their improvement in concept attainment and hierarquization.

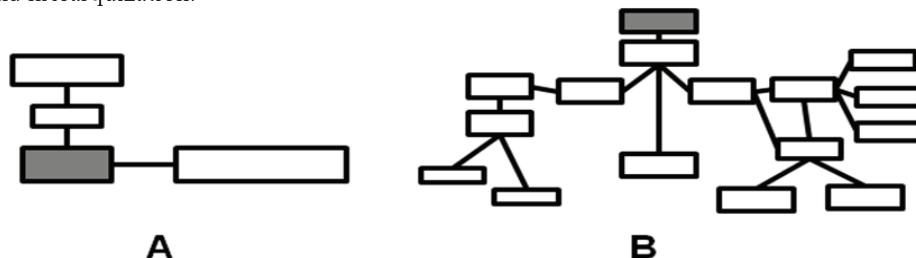


Figure 3: comparison between a student 3's first (A) and the second individual free map (B).

A Figure 3 shows an example of the difference between the first and the second free maps. Fig 3A shows and excessively reduced map. On the other hand, Fig. 3B shows a considerable improvement in organization and concept attainment.

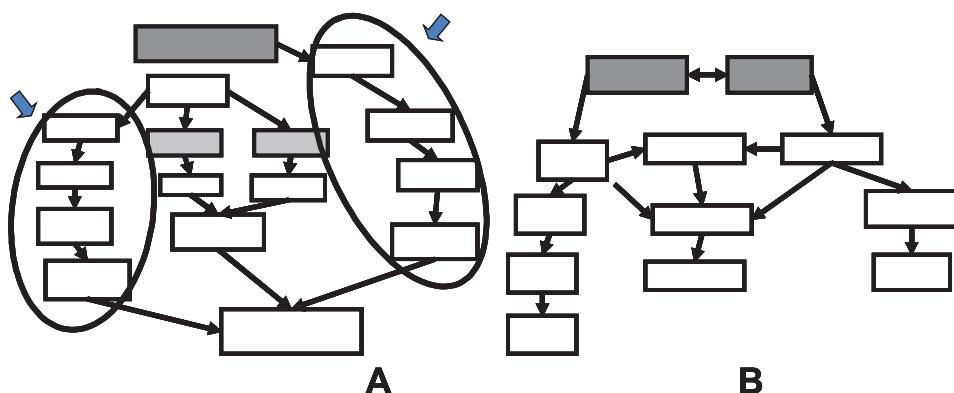


Figure 4: comparison between a student 11's first (A) and the second individual free map (B). Dark grey: main concept; light grey: repeated concepts.

Figure 4 shows another example of the difference between the first and the second free individual map. In Fig. 4A the hierarchical organization is not clear. From the main concept on, we note that there is a linear subordination up to the end of the map. There is no link between the main concept and the immediately subordinated one. Also, there is a concept that was repeated, showing difficulty in understanding the text and therefore difficulty in the organizing information. Fig. 4B shows better organized concepts as there are links among them and, at the same time, it shows a clearer hierarchy. We can also note that there is no repeated concept as in Fig.4B.

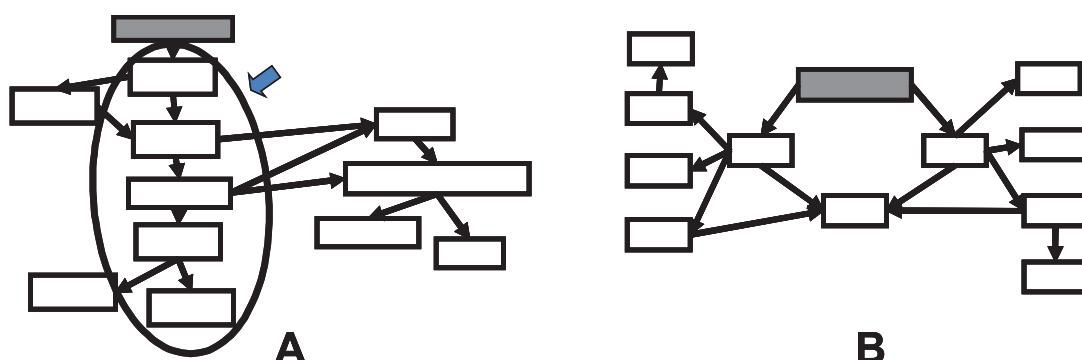


Figure 5: Comparison between the student13's first (A) and the second (B) individual free concept maps

Figure 5 shows another example of the difference between the first and the second free individual map. Fig. 5A shows linear organization in the center of the map. The connections with the left part of the map don't show a clear relation among the concepts. On the other hand, fig 5B shows clearer relations among the superordinate and the subordinate concepts.

Students gradually gained more autonomy and self-confidence: they continuously perceived that meaning is constructed and not something to be searched or reached. This augmented their power of criticism on the texts.

Also, they learned to expose their points of view, as they perceived that they were not detectives searching for some sense, but agents of the construction of meaning.

The overall results indicate that the students in one week only improved their organization of thought, their text comprehension and widened their knowledge and understanding in Evolutionary Biology.

In relation to the discussions along the workshop, we understand that this space for dialog (Bakhtin, 2003, 1981) was crucial to the good performance of the students and the teachers. There was much more than just give them texts and ask them to make maps. The discussions moments were vital for deconstructing rooted beliefs was that the meaning of the text is in the text itself, and that the student's only role was to extract the meaning from it (a behaviorist view) – a common misunderstanding (still present nowadays, even in scientific articles) - in opposition to the socio-interactionist view of reading (search for meaning x construction of meaning).

Considering its relation to Ausubel's theory of anchoring, its possible to affirm that meaning is also a construction the students make in order to learn meaningfully. This point is crucial for the meanings are constructed and that this construction is the only way for learning to happen meaningfully and not be transformed into many memorized concepts or ideas. We believe that learning can only happen when there is critical thinking and a politicized attitude towards life.

4 Future Studies

As students' improvement in reading, reflected on their maps, improved considerably, future studies could systematize and make permanent the work with concept maps involving more consistently the three institutions (UERJ, CBPF, and CPqRR). In order to achieve it will be necessary a long term project with workshop twice a year in two different institutions. An institutionalized research group must be constituted so that students can be accepted work in this research enterprise.

5 Summary

The aim of the workshop was to enhance reading the use of Concept Maps in Evolutionary Biology for Higher Education students. In order to make it happen, we have elaborated a workshop for Biology students at a research center in Belo Horizonte, Brazil. The workshop lasted 15 hours equally distributed in five days. During the workshop the students worked on reading strategies, concept mapping and discussions on Biology issues. We have analyzed students' maps and compared their performance along the workshop. As the results show, there was an outstanding improvement on concept mapping, which pictures their improvement in reading and text comprehension.

6 Acknowledgements

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CONCEPT MAPPING-MEDIATED REFLECTION ON THE DESIGN OF A NEW M.A. PROGRAMME IN HIGHER EDUCATION

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Abstract. After spending a year working on the development of a new online Masters programme in Higher Education, members of the development team were interviewed to reveal their thoughts about the nature of the programme. The dialogue of each interview was summarized as a concept map. Analysis of the resulting maps included a modified Bernsteinian analysis of the focus of the concepts included in terms of their semantic gravity (i.e. closeness to context) and the degree of resonance with the underpinning regulative discourse of the programme. Data highlight a number of issues for programme delivery that centre around the use of appropriate language to manage student expectations in relation to the process of learning and the emotional responses this can stimulate, as well as the tensions that can be fore-grounded between the demands of teaching and research within a university environment.

Keywords: Curriculum Design, Pedagogy, Semantic Gravity, Emotion,

1 Introduction

In setting out to develop a new and innovative M.A. in Higher Education, the programme team (consisting of academic developers and e-learning technologists) spent almost a year discussing the principles that would underpin the programme before starting to consider any of the more instructional aspects of the programme such as learning outcomes, content or assessments. This was revised and discussed on a number of occasions with members of the team free to comment and suggest amendments at any stage along the way. Having then tacitly ‘signed up’ to the foundations of the programme, colleagues then started to construct individual teaching modules and to develop the paperwork required by the university for programme validation.

At this point, the programme leader decided to interview members of the core programme team, as well as colleagues from within the Faculties who were linked with the programme development and who would be involved in ‘marketing’ and ‘explaining’ the MA to potential participants – mostly academic teaching staff within the university. The aim of these interviews was to see how different colleagues may have internalized the nature of the programme in personal and idiosyncratic ways, and whether observed differences and similarities could be used to better inform team preparations for course delivery.

At the outset the team shared a commitment that all modules would not only be *underpinned* by, but also *prefaced* by an explicit pedagogic framework to draw out the integration of the theories and values upon which the programme is built (summarized in Figure 1). Within that framework, the integration of contemporary educational theory was used to emphasize the key concepts of:

Connectivity: in terms of connections between concepts, theory and practice, teaching and research, disciplinary methods, teachers and students. These connections will be made explicit through the application of knowledge visualization using concept mapping (Novak, 2010). This will be explained to programme participants in the non-credit bearing introduction to the programme so that participants are equipped to engage with the pedagogy of the programme as well as the content.

Transformation: in terms of the structure of knowledge and how learning in different contexts requires recognition of the significance of different knowledge structures and how they interrelate. This is informed by contemporary theories such as: threshold concepts, semantic gravity, student-as-producer, meaningful learning. These concepts are emphasized in the integrated depiction of the theoretical basis of the programme offered in Figure 1, showing that participants’ perspectives can start and end with a focus on their own disciplinary expertise. This requires a deviation from the normal concept mapping grammar that only permits a concept to occur in a single node on the map to allow ‘disciplinary expertise’ to form a *central corridor* between the conceptual and experiential components of the framework, with ‘structural transformation’ forming the threshold concept that links the regions of low and high semantic gravity.

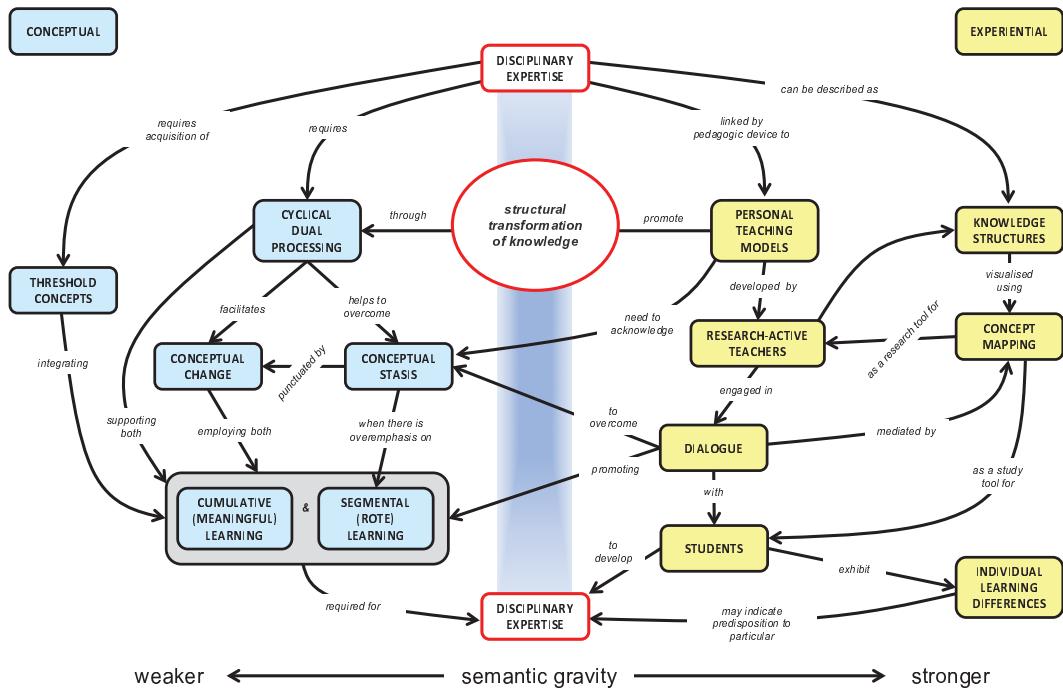


Figure 1: Pedagogic framework for the MA programme (redrawn from Kinchin, 2013).

2 Values underpinning the MA development

The online nature of the programme, and in particular its distance delivery mode, means that it is crucial to fore-ground the pedagogic framework within all the materials presented, as in the absence of extensive face-to-face contact with programme tutors, the participants need the programme structure to be explicit with the course materials. This framework will help to provide coherence across the diversity of content that will be offered. All modules will be guided in their construction by these pedagogic principles, which will also be used in programme evaluation.

2.1 Regulative Discourse underpinning development of the MA in Higher Education

Bernstein (2000) refers to curriculum in terms of its regulative discourse (RD) and instructional discourse (ID). The RD refers to the values that underpin the curriculum. ID refers to content selection, sequencing, pacing and assessment. Bernstein argues that the ID is *always* embedded in the RD, whether the RD is explicit or implicit. Our observations of other programmes suggested that programme teams often focused on the ID without paying explicit attention to the RD, as if the underpinning values were assumed to be a ‘given’. We chose to foreground the key RD components as four key programme principles (after Vorster & Quinn, 2012):

- Contribute to the development of participants' theoretically informed understandings, and teach in ways that support epistemological access for a diverse student body.
- Respect participants' disciplinary backgrounds, and to encourage participants to interrogate the nature of their own disciplines and relate this to ideas presented in the programme.
- Promote reflective practice, requiring critical engagement based on evidence and theory with the roles and practices of higher education teaching, rather than having as its goal the teaching of a set of generic skills and techniques.
- It is often necessary to disrupt participants' existing beliefs about teaching and learning.

This then flows on to the consideration of the 'powerful knowledge' (*sensu* Wheelahan, 2010) that participants should develop over the course of the programme that is required to develop 'expertise' rather than 'procedural competence'. This form of knowledge is a pre-requisite for participants to contribute to the evolution of the theory and practice of the academic field in which they are practitioners – university teaching.

Powerful knowledge is a product of learning described variously as deep (Marton & Säljö, 1976), meaningful (Ausubel, 2000; Novak, 2010) and cumulative (Bernstein, 2000; Maton, 2009), in order to generate qualitatively rich understanding that is in turn related to appropriate practice knowledge (Kinchin and Cabot, 2010, Maton, 2014). Young and Muller (2013: 245) consider knowledge as being powerful when it '*frees those who have access to it and enables them to envisage alternative and new possibilities.*' Maton (2013) described a universal desire for the construction of this type of knowledge that aims to generate ideas that have utility beyond the specifics of their originating contexts. He has developed this argument to make the statement that:

"A spectre is haunting education – the spectre of segmentalism. This affliction occurs when knowledge or knowing is so strongly tied to its context that it is only meaningful within that context."

(Maton, 2014: 106)

Characteristics of teaching that will support a move away from segmentalism have been specified by Biggs (2003: 17), including:

- Make the structure of the subject explicit
- Encourage the active participation of students
- Build on what the students already know
- Assess for structure rather than independent facts

The regulative discourse underpinning the programme will inevitably have a weaker semantic gravity (i.e. it is less context-specific) than the more transparent (and practicum-focused) instructional discourse (figure 1), and so it is anticipated that initially it will prove more challenging to most programme participants. It is within the aims of the programme to help participants to relate these discourses and their concomitant knowledge structures as they '*ride the semantic wave*' (*sensu* Maton, 2013; 2014), and develop their expertise in the field of higher education.

3 Concept mapping-mediated interviews

An aspect of the method we have adopted in this research project that requires further discussion is the nature of the concept mapping-mediated interview (Kandiko Howson & Kinchin, 2014). The standard interview set-up requires the interviewer to present questions to the interviewee in order to gain access to the interviewee's individual insights and personal perspective. This is achieved by engaging in dialogue (verbal or textual) that is by its very nature linear in structure. Within that linear narrative, it is then up to the researcher-interviewer to determine the underlying structure within that dialogue to construct an interpretation of the interviewee's understanding. In essence, the interviewer has to interrogate the interviewee's invisible knowledge structure.

Within the concept mapping-mediated interview, the dynamic between the interviewer and interviewee is changed in a subtle, but important way. Here it is the interviewee that exposes his/her knowledge structure through the emerging concept map, shown in previous studies to be the ideal tool to make learning visible and externalize the relationship between public and personal learning in higher education (Hay et al., 2008; Kandiko et al, 2013;). The interviewer's job is then to prompt the interviewee with questions that will encourage him/her to interrogate his/her own knowledge structure. This means that the interviewer no longer has to impose a structure on the linear narrative, but rather interpret the structure that has emerged from the dialogue (Kinchin, Streatfield and Hay, 2010). This process makes it less likely that the interviewer will impose an inappropriate knowledge structure based on his/her prior conceptions. Whilst no restrictions were verbalized to the mapper in terms of the number of concepts to be included, the process used 38 x 50mm self-stick notelets to act as the nodes on which the concept labels were written, and these were affixed to a sheet of A3 paper, so that once the sheet was becoming full, the interviewees tended to stop adding new ideas.

4 Map analysis

Ten concept maps were produced: three by academic developers, four by e-learning technologists and three by faculty representatives. Within the ten maps, 96 different concept labels were recognized, with 74 of these each used only once by a single mapper. Only 8 concept labels were used 3 or more times: practice (7); discipline (5); research (5); new technology (3); online (3); PGCAP/Grad Cert (3); career (3) and teaching (3).

That only ‘practice’ (in terms of ‘professional practice’ and ‘academic practice’) was included in all the maps produced by the seven members of the programme team is of interest, as it was seen by the team to be crucial to link the theory presented within the programme with the practical activities of the participants’ working lives. The use of practice seems to emphasize the processes involved in professional development. In contrast the three maps produced by the faculty representatives did not feature ‘practice’ at all, but referred to the more goal-orientated products of the programme – in terms of career development and promotion. This difference in perspective (from process to product) may have important consequences for the language used in marketing the programme to colleagues based in the academic faculties.

4.1 An academic developer’s map

Space allows for the discussion of just two of the maps gained in this study. The map in figure 2, was produced by an academic developer who was involved with the programme development from the outset and was ultimately responsible for the development of one of the teaching modules.

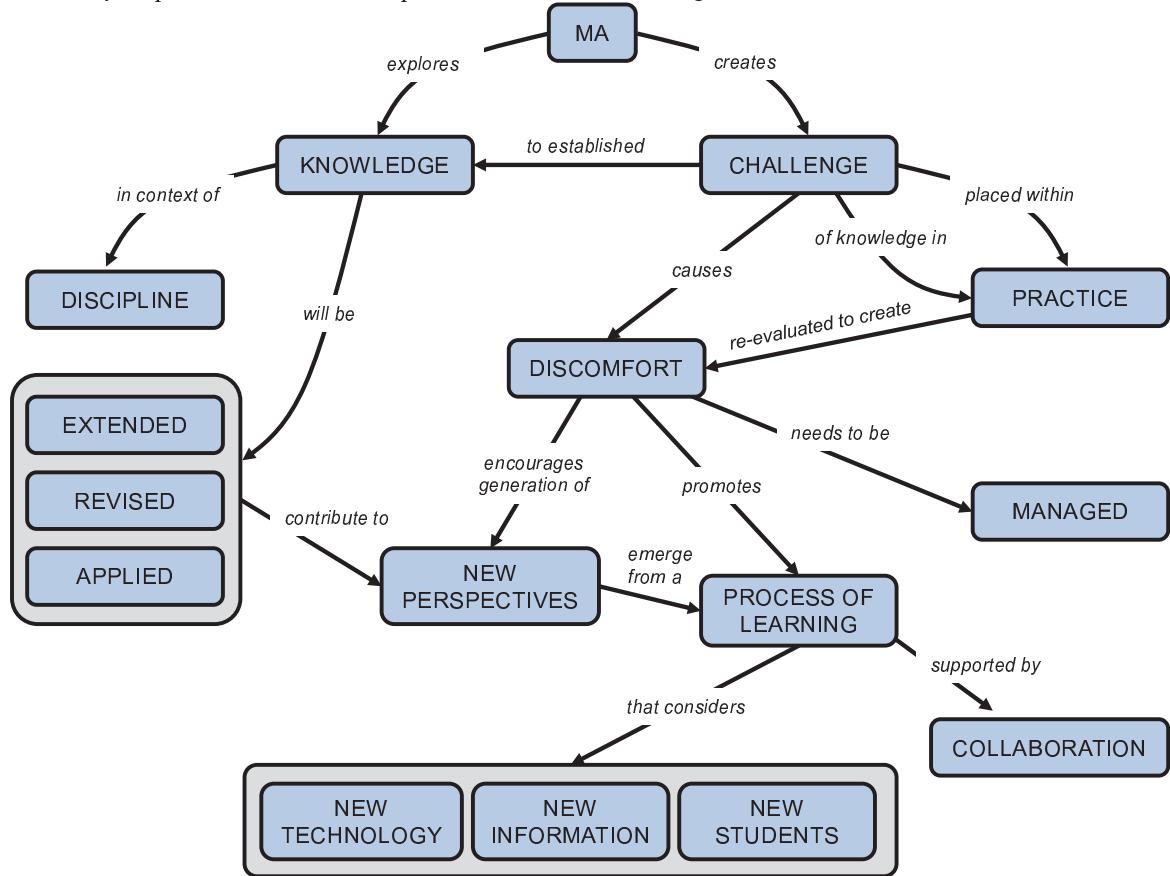


Figure 2. Map produced by an academic/faculty developer.

The map in figure 2 concentrates on the MA’s role in extending and revising knowledge to offer new perspectives. In the classic paper by Posner *et al* (1982), those authors present a model of conceptual change which articulates the process by which people’s central, organizing concepts change from one set of concepts to another set that is incompatible with the first. They consider learning to be a rational activity whereby ideas are accepted because they are intelligible and fit with available evidence. Students use existing concepts to deal with new phenomena (assimilation), but when these concepts are inadequate, the student must replace or reorganize the central concepts (accommodation). The authors propose the following conditions as necessary for conceptual change: there must be dissatisfaction with existing conceptions; a new conception must be intelligible; a new conception must appear initially plausible; and a new conception should have the potential to be extended.

The map author of figure 2 has not described this in terms of the ‘cognitive conflict’ described by Posner *et al* (1982), but has opted for the term ‘discomfort’, that suggests a greater consideration of the affective domain within the process of learning (e.g. Beard *et al.*, 2007). Rowe *et al.* (2013) have considered the role of positive emotions in the learning process and have referred to ‘passionate inquiry’ as a source of such emotions.

Specifically, positive emotions (particularly *interest/excitement* and *love*) were seen to be associated with a curriculum perceived to be relevant to the learners' needs, and delivered by genuinely engaged teaching staff. The RD of the programme here was developed with the explicit intention of "*starting and ending with the participants' discipline*" (Figure 1), to ensure relevance to practice. This has re-emerged in a number of the programme team's maps, although in practice 'relevance' may be a more difficult notion to foster among students in the early weeks of a programme when working at distance in an online environment (Marchand & Gutierrez, 2012).

When constructing a curriculum there is an implicit view of the student embedded within the pedagogical framework and in the selected content to be covered within the programme. Ulriksen (2009) has developed the concept of '*the implied student*' to make explicit the relationship between the expectations of the students, teachers and institution. Ulriksen (2009: 522) sees the implied student as drawing attention to the unspoken anticipations about what studying is and what the meaning of the study is whilst emphasizing the structure of the programme, the mode(s) of teaching and the teachers' expectations. He summarizes this as:

"the study practice, the attitudes, interpretations and behaviour of the student, that is presupposed by the way the study is organized, the mode of teaching and assessment, by the teachers and in the relations between the students, enabling the students to actualize the study in a meaningful way."

As the 'students' on this programme will also be university staff, who by various measures will already have been 'successful students' within their home discipline, there will be some expectation that programme participants will already possess some study skills (though these may be discipline-specific), and that participants will also be proactive in their studies, with some internal motivation for undertaking this particular programme. The experience of the academic developers within the programme team was such that they anticipated the primary focus of their implied students would be their home discipline (rather than education *per se*), and that the motivation for engaging in this programme would be to further their disciplinary standing, rather than to 'migrate' into education or the social sciences more generally.

4.2 A faculty perspective map

The two main clusters of concepts within the map in figure 3; the network to the left starting with 'pedagogy' and the chain to the right starting with 'professionalism', indicate a structural divide that suggests a conceptual component and a procedural component that also reflects difference in semantic gravity. The pedagogy network indicates a low semantic gravity, whilst the professionalism chain indicates a high semantic gravity (a close link to practice). The challenge for the MA programme is to build a bridge between these opposing elements that provides an indicator of expertise (Kinchin and Cabot, 2010).

The small cycle at the top left of the map (between pedagogy and discipline) is also of great significance to the author of this map who explained that the pedagogy of the discipline is embedded in the discipline rather than being something that is imposed on the discipline from the outside. The map author sees this as a major obstacle in getting academics to see teaching as an integral part of their role within the university, rather than something that is in conflict with their role as researchers. This view resonates strongly with the position outlined by DiCarlo (2006) when he stated that *biology should be taught as science is practised*, and also with the study by Aydeniz and Hodge (2011) who found that the identities of a professor as a teacher or a disciplinary expert can be in tension with structural elements of the workplace that discourage the enactment of teacher identity. A similar phenomenon has been noted in the Arts where tutors report experiences of 'being in two camps with tension and separation between them' (Shreeve, 2011: 89). Therefore, whilst the dynamic tension illustrated between 'pedagogy' and 'discipline' is framed in a very positive and mutually beneficial manner here (e.g. 'complementary to', 'feeds into'), if this relationship becomes more negative, it may put the enactment of the whole pedagogy network (on the left hand side of the map) under threat.

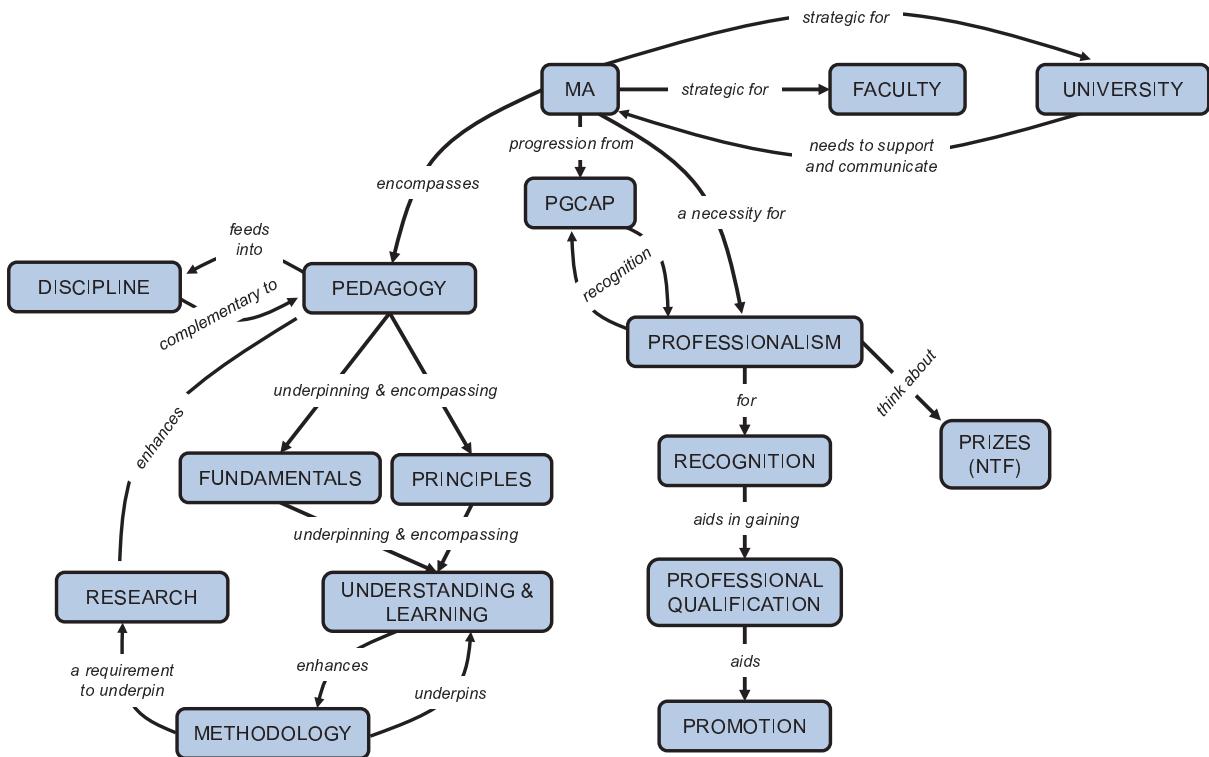


Figure 3. A faculty perspective map.

The culture of the workplace could be seen to favor ‘discipline’ in a manner that is detrimental to the development of reflection on the fundamentals and principles that are seen to underpin learning, with research productivity perceived to be of higher value than teaching productivity (as described by Young, 2006 and reiterated by Alpay and Verschoor, 2014). It is exactly this sort of tension that has been seen to drive institutions towards reliance on ‘non-learning outcomes’ (*sensu* Kinchin, Lygo-Baker and Hay, 2008). Novice university teachers have been shown to view teaching and research within the same discipline to be epistemologically separate (Kinchin et al., 2009). Unless this issue is addressed, and the pedagogy of the discipline is recognized as being a fundamental part of the discipline, the structural separation of teaching and research is likely to persist. The author of map 3 appears to be suggesting that if an academic is not an expert in the pedagogy of his/her discipline, then they are not expert in the discipline.

5 Summary

A number of general issues were raised by this concept map-mediated reflection on programme design and delivery:

- The language used within the team of academic developers and e-learning technologists may not quite fit with that used within the faculties. Whereas the use of ‘practice’ is understood within the programme team and may indicate a focus on processes, the preferred use of ‘career’ or ‘professional development’ seems to suggest a more goal-orientated focus within the faculties.
- There are implications within these data for the usefulness of online staff profiles. Many academic staff profiles will include a very few lines to summarize, “I teach on Education 101”, but the contents of the maps presented here really ask questions about what that actually means and how much variation in interpretation of ‘teaching’ there may be. Whilst a student may interpret the statement as, “I tell you what you need to know to pass Education 101”, some of the staff represented here may actually be saying, “I help to manage your discomfort while you learn Education 101”, or “I will engage in dialogue with you about Education 101, and expect you to respond”. The teaching staff represented here will be encouraged to revisit their online profiles to offer a more detailed perspective on their teaching and the expectations they will place on the students within the programme.
- Management of discomfort will require that programme participants are comfortable with aspects of their practice (often the procedural aspects of their jobs) to allow them the confidence in exploring the discomfort in other aspects (often the more conceptual aspects of their roles). Discomfort should

therefore be focussed on the areas of weak semantic gravity – the conceptual. The areas of strong semantic gravity need to provide stability as a platform for their learning to be realised.

- The importance of emotions in the learning process was recognised by members of the programme team, but was often expressed in a potentially negative manner (in terms of ‘discomfort’ or ‘disruption’) which may create anxiety among course participants. Whilst this language was considered appropriate for the internal dialogues between the team members, it was considered sensible to develop a language for a more positive transmission of emotions with the programme participants, and this was a function of the ‘exploratory space’ offered by the programme in which dialogue could be used to support learning rather than generate anxiety.

The reflective process described here can help to stimulate discussion among the programme team, and emphasizes the need to make assumptions about teaching and learning explicit to students on the MA programme. Future iterations of this reflective process will incorporate reflection on students’ maps to help evaluate how the programme has addressed the students’ learning needs.

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CONCEPT MAPS AS A STRATEGY TO ASSESS CHEMISTRY LEARNING IN SHORT FILM PRODUCTIONS BY HIGH SCHOOL STUDENTS

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Abstract. Chemistry is a course that develops student explanations of everyday life phenomena. Several researchers discuss about tools that help chemistry teachers to facilitate students' understanding of chemical knowledge. Among these tools, the commercial cinema is a promising one. However, there are a few reports on the production of short films by high school students as a strategy for promoting meaningful learning in chemistry. This paper presents findings about how making short film production in high school helped to learn chemistry. Concept maps were used to evaluate connections between chemical concepts and scripts developed for the short film productions. Each high school student made two maps, one before and another after the production. The chemistry teacher monitored student's productions through a social network, the Facebook, as well as during the regular classes. The comparison between initials and finals students' concepts maps showed improvement on the students' understanding about chemistry. More than that, our results indicated that 79% of high school students made conceptual maps with elements from their own short film production scripts. Therefore, the activity of producing short films helped to promote meaningful chemistry learning.

Key words: concept maps, chemistry learning, short film production

1 Introduction

According to Gabel (1999) Chemistry is a complex science due to some abstract concepts, which may lead to extensive misconceptions among students. There are many tools used in the Chemistry teaching to facilitate chemical knowledge construction, for example, experimentation, simulation, video, etc. There are studies about how to use cinema for learning. However, we found a few data concerning cinema as a didactic strategy in this discipline.

Cinema is the audiovisual version of storytelling. Life stories and narratives enhance emotions and therefore set up the foundation for conveying concepts. Movies provide a narrative model framed in emotions and images that are grounded in the students' familiar everyday universe. Thus, the cinema is an excellent educational tool because it presents situations as if they are lived by the protagonists, mimicking social reality, but with the great advantage of re-observe the scenes when necessary. It is possible, afterwards, to have discussions of social issues at the same time as learning chemistry. Another method utilizes certain scenes of commercial movies, adequately selected, to introduce determined social behaviors in the Chemistry teaching (Santos & Aquino, 2011). In addition, students have the opportunity to "translate" movie life histories into their own lives, and into a chemistry context, even when the movie does not belong to the chemical field. They shed light on socio-cultural elements and discuss big ideas like citizenship and social responsibility, while using the universal kind of language, images. All of this transform concepts into emotions, which can inspire student's actions.

Flipping these strategies above, we can have students building short films about chemistry themes as a way of learning. Since film has the potential to fascinate, inspire and educate students, opening their minds to the world around them, the idea was to introduce short film productions not just as a passive form of entertainment, but also as a powerful active learning tool for chemistry learning process. The questions are, "Is it possible to learn Chemistry by building short films? How to do this? What may be learned from this experience?" These questions are the basis of this study.

Knowledge building is a system with elements that necessarily supported on one another while, at the same time, these are opened to multiple exchanges with the outside (Piaget, 1995). The development of the human cognitive process is based on that. Thus, learning process assumes it is impossible to build a single knowledge as a starting point in a classification without using other domain-related knowledge, which characterizes a non-hierarchical, dynamic process of interconnected variables. In this way, meaningful learning, as defined by Ausubel (1968), happens when new knowledge connects with previous knowledge ultimately creating life-long learning.

The Ausubel's theory of meaningful learning constitutes a basis for Chemistry teaching by short film productions. The production of short film was a learning tool and fit the characteristics of meaningful learning described by Jonassen et al (1999) shown in Table 1.

Thus, meaningful learning requires conversations and group experiences and aiming to create a learning environment able to stimulate critical thinking. In order to foster students engaging in meaningful learning we used a combination of technological elements. This environment enabled cooperation to produce short films. Vygotsky's theory of social cognitive development states, "social interaction plays a fundamental role in the development of cognition" (Vygotsky, 1998). Vygotsky's Theory of Social Cognitive Development argues that social interaction plays a fundamental role in the development of cognition. Another notable aspect of Vygotsky's theory is it claims, "Instruction is most efficient when students engage in activities within a supportive learning environment and when they receive appropriate guidance that is mediated by tools" (Vygotsky, 1998). In the short film productions to promote meaningful learning teacher guidance is fundamental to achieve students learning and activity success.

Table 1: Characteristics of meaningful learning (Jonassen et al, 1999)

Characteristic	Description
Active	Students interact with the environment, manipulate objects and observe the effects of manipulation
Constructive	Students must reflect on the activity and their observations, and interpret them in order to have a meaningful learning experience.
Intentional	When students actively try to achieve a learning goal they articulate, think and learn more.
Authentic-	Learning is meaningful, better understood and more likely to transfer to new situations when it occurs engaged with real-life, complex problems
Cooperative	Each person lives, works and learn in communities, naturally seeking ideas and assistance from each other, and negotiating and solving problems. Meaningful learning, therefore, requires conversations and group experiences.

According to Ausubel (2000) the new learning was meaningful when it could be related in a non-arbitrary way to that which a student already knew. When student's existing cognitive structure takes new information and this relates to the previously learned content forming new connections between this new information and the existing information, meaning happens.

This learning may be promoted through concept mapping by the student's ability to not only create meaningful learning, but to transfer knowledge gained before to future problems as well. Concept mapping facilitates the student's ability to organize information, assess existing knowledge gains, develop insights into new and existing knowledge and transfer knowledge to new experiences. Regardless, concept maps can facilitate students' understanding of the organization and integration of important concepts (Pinto & Zeitz, 1997). By connecting old and new knowledge, this type of learning clarifies knowledge, improves critical thinking and assists in completing missing knowledge (Beitz, 1998).

Novak and colleagues developed concept mapping in 1972. At that time, concept maps were used to represent the conceptual network established by students throughout elementary and high school, which resulted in a longitudinal study of conceptual change in science education (Novak & Musonda, 1991). The initial milestone occurred before the birth of concept maps (1972) when David Ausubel published Assimilation Theory of Meaningful Learning and Retention (Ausubel, 2000). Although it is important to use concept maps appropriately for educational purposes. Previous studies indicate that there are two dominant processes for creating concept maps in classrooms. One process occurs when students are fully responsible for creating the concept maps by themselves without the aid of subordinate concepts, and linking words/phrases (Yin et al., 2005). The other process happens when teachers provide students with the structure of the concept map, the superordinate concept, the subordinate concepts, and linking words/phrases and are required to fill and complete the concept map to show the appropriate relational propositions (Yin & Shavelson, 2008). In chemistry, the use of concept maps has been widely investigated. According to previous studies (Markow & Lonning, 1998; Pendley et al., 1994), concept maps help chemistry learning both in classrooms and in laboratories. In this way, concept maps can improve understanding of chemical concepts and help build connections among abstract

concepts and bind concepts with linking words that help students see connections among them and organizes the knowledge hierarchically, based on scientific knowledge (Francisco et al., 2002; Nicoll et al., 2001).

A concept map is not just a learning tool, but also an ideal evaluation tool for educators measuring the growth of and assessing student learning. When students create concept maps, they explain ideas using their own words. The map helps to identify incorrect ideas and concepts. Educators are able to see what students did not understand, providing an accurate, objective way to evaluate areas in which students do not yet grasp concepts fully. In this way, concept maps are an important tool to analyze how the short film production can promote the meaningful learning in the chemistry teaching.

In the present work, we used concept maps as tools to represent knowledge to support students' expression before and after producing their short film. This means that students concept maps represent students concept systems of preexisting knowledge, as well as activate later constructions, and possible subsystems of signification associated with the content at chemistry. Analyzing student's concept maps, we aimed to understand the student's knowledge of the determined chemistry topic and the influence of the use of short film production as a strategy for learning this determined chemistry topic.

2 Methodology

The experience developed during seven months in the Colégio de Aplicação da Universidade Federal de Pernambuco (CAp-UFPE), a public Brazilian high school, with 53 students in their final year, in the chemistry course (three weekly classes). The project was named QUIMICURTA.

Students gathered themselves into five groups by affinity. Each group produced a short film using chemistry concepts. The short film productions was an extra-class activity and the guidance of the teacher happened weekly by social network, Facebook, and, sometimes, during regular classes.

The project evaluation focused on two aspects, quality of short film and chemistry concepts applied in that production. In addition, all students made individual concept maps. The data analysis used two conceptual maps made by each student: (a) one map before initiating the short film production and (b) the second just after the short film production. This analysis used the following criteria: correct chemical concepts and relationships with related ideas, number of relationships (levels) and concepts from student's film scripts.

The number of relationships or levels of concept maps used were (authors' classification): i) N1=one level; ii) N2=two levels; iii) N3=tree levels and iv) N4=four or more levels. In this study, the number of relationships was the first visual comparison between initial and final maps.

3 Findings

3.1 Short film analyzes

The Table 2 shows the chemical themes and the script abstract produced by students for short film productions. Each group developed one theme and chose the film characteristics.

To develop contextualized stories students used all chemistry themes. Teacher's monitoring of students development of short film productions through social network showed all students made meaningful decisions about how to apply chemical concepts in their stories. Sharing knowledge between colleagues and teacher gave students an opportunity to engage in discussions, take responsibility for their own learning and, thus, become critical thinkers. Critical thinking is valued at all levels of meaningful learning. The process of promoting critical thinking in on line space involves comprehension that students must be meaningfully motivated and encouraged to improve their thinking skills. Therefore, critical thinking and meaningful learning are interrelated. The social themes that all films showed reinforce this interconnection.

Table 2: Chemistry themes and abstract of short film production

Chemical concept	Script abstract
Isomerism	Use of Thalidomide by a high school student who became pregnant.
Polymer	Use of a polymer bulletproof vest to prevent a homicide.
Organic Function	Use of chemicals to promote coffee traffic.
Addition reaction	The history of a margarine manufacturer from vegetable oils.
Oxidation-reduction reaction	The wine oxidation and the use of Breathalyzer in the road traffic.
Ester reaction	The development of an advertising campaign for a liquid soap.

3.2 Analysis of Concept Maps

The student's initial maps indicated that all students had some previous knowledge about the proposed concept of chemistry used to short film production. All students' final concept maps expanded initial concepts as compared to the initial maps, something easily noticed by a mere glance at the size of the maps.

Table 3 showed the number of levels found in the preliminary concept maps analysis. Some initial maps presented a few concepts and relations. A purely visual comparison between the maps indicated that students added new elements, reinforcing the opportunity of using concept maps in the learning process of the chemistry. In addition, most maps (79%) presented elements of the scripts developed for the production of short films. It reveals that the process of producing the short films led to new connections between prior knowledge and new knowledge and that this strategy can support the promotion of meaningful learning.

There were maps that do not had scripts elements showing interrelation between concepts, so they did not characterize as fragments but as parts of a whole. Students with fewer representations in the initial map presented more expansion on the final map, probably influenced by group activity and class discussions.

The analysis of Table 3 showed more occurrence of N2 to N3 transitions followed by N2 to N4 transitions. If a student has relevant information in their cognitive structure to relate a new knowledge, the level number in the maps may represent this connection, and then, meaningful learning can happen. However, meaning happens when, and only when, a learner incorporates new information into their cognitive structure and relates that to which he or she already knows to form new meaning. The data showed the final maps that have remained with the same number of levels had greater organization of concepts and preserved the uniqueness of the new content. Figures 3 and 4 show example of N4 to N4 transition.

Table 3: Comparison of the number of levels in the concepts maps produced before and after short film productions.

Level number before short film production	Level number after short film production	Occurrence percentage (%)
N1	N1	1.89
N1	N2	7.55
N1	N3	1.89
N2	N3	39.62
N2	N4	32.07
N4	N4	16.98

Concept maps from two students were randomly selected to illustrate data analysis. Figures 1 e 2 show examples of the initial and final concept maps, respectively, drawn by the same student 1. Figures 3 and 4 are the initial and final concept maps of student 2. The result of maps analysis of other students was similar to one described in this paper.

In the initial map of student 1 (Figure 1) demonstrated only rudimentary knowledge of organic functions, which was the topic used in the short film production of his group. Student 1 only connected a simple classification of the organic functions and the correspondent structural molecular form. In addition, student 1 showed difficulties in the relationship between amide function and its structure. No relation was found in amide concept.

The comparison of Figure 1 and the final map represented in Figure 2 showed N2 to N4 transition. It indicates there was not only a highly significant increase in organic function knowledge, but also this knowledge was consolidated.

Accurate relationships between concepts related to organic function and the script used in the short film production was evident in Figure 2. The induction of "everyday applications" reinforce this conclusion. The scrip of short film produced by group of student 1 based in the everyday applications of chemical substances. In a short film script, traffickers sold coffee as a drug and killed people who did not want to attend traffic with chemicals. In order to contain the traffic of coffee the police opened an investigation. Terms like "medicines" and "solvents" have a direct connection with the script built by the group.

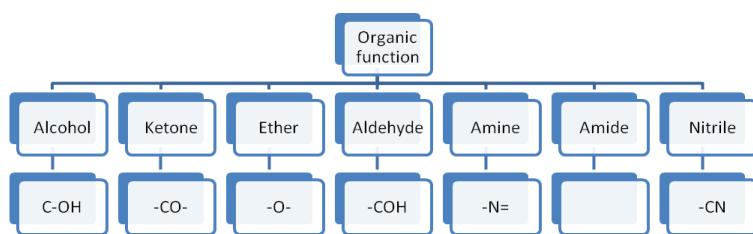


Figure 1. Initial concept map of student 1 presents some previous knowledge about organic function

Thus, student 1 added significant interrelations to organic function concepts and the process of progressive differentiation was evident. The activity of researching, prior to make a short film production, seemed to facilitate this process. The progressive differentiation is the meaningful learning process of introducing new content at its highest level of generality or abstraction and then progressively getting more specific about that content as you compare it with other content that exists within a person's cognitive structure (Ausubel, 2000). In this way, Figure 2 shows a more contextualized relationship of organ function classification, but with a much lower degree of importance. Thereby, student 1 showed a significant broadening of chemistry knowledge. He also showed us the production of the short film played an important role in this new knowledge construction.

Student 2 reached similar results in his production about ester reaction. Figure 3 showed a simple connection between the ester reaction and only two types of reactions, esterification and hydrolysis. Student 2 produced only tree levels of connections. It is a basic knowledge about ester reaction.

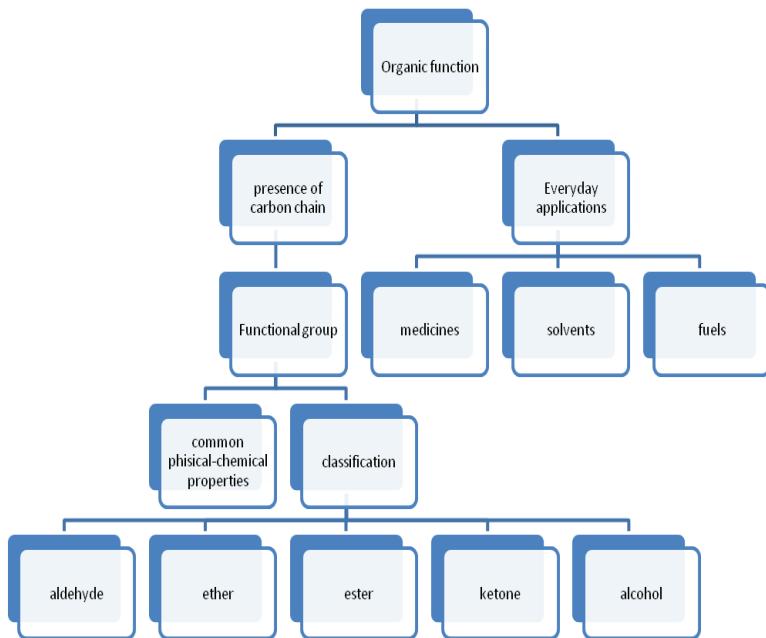


Figure 2. Concept map of student 1 after short film production

The short film produced by student 2' group focused on the development of an advertising campaign for a liquid soap. Besides the characters work in an advertising agency, they filled up their cars with gasoline. However when arriving at the gas station, they were approached by the employee who tried to speak about biodiesel advantages. Thus, student 2 showed the interrelations between the previous knowledge and the knowledge construction from short film production in the sequence of connections: "ester reaction"→"everyday"→"biodiesel" and "soap and cleaning products". The quantitative analysis of maps showed N4 to N4 transition, but the qualitative analysis showed a final concept map (Figure 4) more hierarchically organized and differentiated. It seemed to occur the progressive differentiation process.

Student 2 also represents the classification of ester reactions in the final concept map. However, the term "hydrolysis" disappears and becomes implicit in the reaction of soap production when the term "ester + sodium hydroxide" appears on the map in Figure 4. The integrative reconciliation process seemed to happen in this case. The integrative reconciliation process occurs when the new knowledge is compared with the existing knowledge to show similarities (Ausubel, 2000).

In essence, progressive differentiation points out differences, or contrast, while integrative reconciliation points out similarities, or comparisons. By using these opposite processes in the knowledge construction, student 2 could maintain at the same time the distinctness of a new idea through progressive differentiation and showed the similarities of this idea with other known ideas through integrative reconciliation.

Student 2 also represents the classification of ester reactions in the final concept map. However, the term "hydrolysis" disappears and becomes implicit in the reaction of soap production when the term "ester + sodium hydroxide" appears on the map in Figure 4. In this specific observation, it seemed to happen the integrative reconciliation process. The integrative reconciliation process occurs when we compare the new knowledge with the existing knowledge to show similarities (Ausubel, 2000).

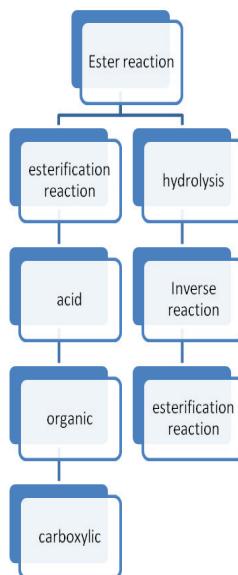


Figure 3. Initial concept map of student 2 presents some previous knowledge about ester reaction

It is reasonable to think that changes in the final map made for students correspond to changes in the conceptual structure of the student. That happened due to their participation in the short film production about the chemistry elements. Cognitive structure represents both the content of that which we already know and its organization. Our cognitive structures are organized with the larger, more inclusive, abstract ideas and concepts at the top. Information that is more specific resides at lower levels within our cognitive structures. For example, the concept of chemistry reactions would reside at a higher level in a cognitive structure than the concept of addition reaction, and the concept of addition reaction would reside at a higher level in the cognitive structure than the concept of hydrogenation. The cognitive structure is a key concept influencing learning according to Ausubel (2000). A learner has to have a relevant prior knowledge in his or her cognitive structure to which related the new information.

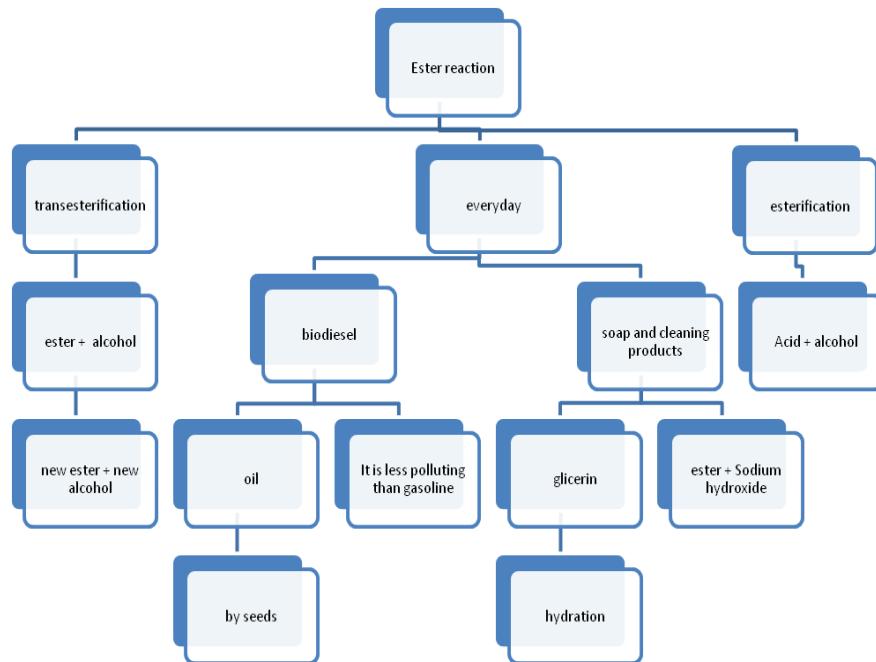


Figure 4. Concept map of student 2 after short film production

3 Summary

Cinema is the audiovisual version of storytelling. Life stories and narratives enhance emotions and therefore set up the foundation for conveying concepts. Movies provide a narrative model framed in emotions and images that grounded in the students' everyday universe. Students have new learning opportunities when the teacher

leaves the walls of traditionalism and realize new ways of teaching, for example, using cinema as an educational tool. Our findings showed that short films productions not only mobilized students for an extra class activity, but also promoted a more dynamic learning in the discipline of chemistry. The construction of a concept map permitted the representation of knowledge before and after short film production. It worked as processes of assimilation and adaptation of new mental schemes, in terms of reflective abstraction.

What about our initial question: Was it possible to learn Chemistry developing short films? Yes, it was. Our results supported this answer. In Ausubel's cognitive theory the importance of practice is to provide opportunity for the internal processing by which new information is brought into a cognitive structure, sorted out, and connected with other information so that it becomes anchored in a meaningful manner and, thus, learned. However, every new educational practice requires creativity. Creativity is the field of imagination, inventiveness, divergence. Creativity relates to intelligence, being an association and a transformation of known elements to get a good new original result. Creativity makes it possible a great variety of ways to solve the same problem. To use the teacher's imagination and inventiveness makes students get new and divergent results. The QUIMICURTA project described in this paper is an example about creativity in the chemistry teaching and learning.

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CONSTRUTOS DA OBRA DE JEAN PIAGET: DESENHANDO UMA TEORIA CONSTRUTIVISTA PARA OS MAPAS CONCEITUAIS

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Resumo. Neste artigo delineamos uma base construtivista para os mapas conceituais segundo o paradigma da Epistemologia e da Psicologia Genética – nome dado por Piaget ao corpo teórico construído com a ajuda de muitos colaboradores. Do ponto de vista epistemológico, nossa intenção é delinear uma correspondência entre o processo de construção dos mapas conceituais e o processo de conceituação descrito por Piaget ao longo de diversos trabalhos de sua extensa produção teórica.

Palavras-chave: Piaget, mapas conceituais, construtivismo.

1 O processo de conceituação segundo a Epistemologia Genética

A posição epistemológica de Jean Piaget estabelece que o desenvolvimento das estruturas lógico-matemáticas no sujeito está relacionada à aprendizagem de maneira geral ou, especificamente, à aprendizagem de conceitos. Ao contrário de outras posições epistemológicas, a vinculação entre desenvolvimento e aprendizagem não implica um processo linear de elaboração do conhecimento e sim uma construção conjunta: o desenvolvimento das estruturas lógicas ocorre como condição necessária às aprendizagens e ele se dá em virtude das experiências materiais – na ação direta no mundo físico sobre os objetos – ou virtuais – ações ou coordenações no pensamento – do sujeito (Piaget, 1970, 1990). Uma primeira aproximação em torno da teoria dos mapas conceituais pode ser feita a partir da comparação entre o mapa conceitual e a expressão das estruturas lógicas em torno dos conceitos relacionados no mesmo. Nesse sentido, podemos afirmar que, considerando critérios de análise específicos, a construção de um mapa conceitual pode auxiliar na investigação sobre as estruturas lógicas que esse sujeito consegue mobilizar para operar conceitualmente.

A Epistemologia Genética de Jean Piaget coloca em evidência a atividade do sujeito como condição necessária à aquisição de novos conhecimentos. Para ele, o conhecimento “resultaria de interações que se produzem a meio caminho entre o sujeito e o objeto, e que dependem, portanto, dos dois ao mesmo tempo, mas em virtude de uma indiferenciação completa e não de trocas entre formas distintas” (Piaget, 1970/1990, p.8). Há, portanto, no decorrer do desenvolvimento cognitivo, uma elaboração solidária tanto da consciência do sujeito sobre si mesmo quanto da distinção de um objeto como tal.

Piaget organiza seu modelo de desenvolvimento cognitivo considerando estágios caracterizados pela predominância de determinadas ordens de condições e que ocorrem progressivamente. Contudo, pode-se encontrar características de um estágio mais avançado mesmo que se possa classificar determinado sujeito em um outro devido à frequência maior de ações ou operações de ordem inferior.

A cargo desse processo de desenvolvimento está a função cognitiva de adaptação, constituída na regulação e auto-organização das trocas do indivíduo com o meio. Essa função engloba dois processos indissociáveis e que tendem a um equilíbrio, em geral nunca atingido a não ser a título de etapas provisórias (Piaget, 1975/1976). A definição de tais processos expõe a perspectiva dialética das interações entre sujeito e objeto propostas no modelo de Piaget: a) assimilação é a incorporação de um elemento exterior a um esquema de ação ou a um conceitual do sujeito; e b) acomodação é a necessidade em que se acha a assimilação de levar em conta as particularidades próprias dos elementos a assimilar.

O resultado da assimilação é a constituição das significações do sujeito. Essas significações inicialmente integram os esquemas de assimilação, que são generalizações das possibilidades da ação. Resulta que a acomodação, enquanto processo, tem a função de diferenciar os esquemas de assimilação. Em decorrência das implicações da atividade do indivíduo nas interações com o meio, os esquemas de assimilação coordenam-se em sistemas, progressivamente estruturando o que Piaget chama de sistema de significações do sujeito. No modelo piagetiano, é a equilibração cognitiva o mecanismo que explica as regulações, desencadeadas por perturbações (assimilação das novidades), que são responsáveis, seja na ação ou posteriormente usando representações, pelo desenvolvimento das estruturas (lógicas) que asseguram as condições para as aprendizagens do sujeito.

Se, inicialmente, fizemos a aproximação entre mapas conceituais e o uso de estruturas lógicas, podemos ampliar esse desenho de um modelo piagetiano dos mapas conceituais fazendo a seguinte relação: no processo de construção de um mapa conceitual, o sujeito, ao realizar escolhas relativas à conceitos e as respectivas frases de ligação, em ultima análise, estão realizando uma representação dos sistemas de significação ativados em relação ao conjunto de conceitos ali descritos.

No intuito de explicar o desenvolvimento das estruturas cognitivas pelo processo de equilibração, Piaget postula a existência de três tipos de leis de equilíbrio: entre os esquemas do sujeito e os objetos; entre os sistemas e subsistemas relativos à mesma classe de objetos ou de ações; e entre os sistemas parciais em suas diferenciações e o sistema total em sua integração. De maneira geral, Piaget chama de regulação (Piaget, 1975/1976, p.24) ao processo de retomada das ações e/ou operações com modificações a partir dos resultados obtidos na ação (ou operação) anterior. O papel de tais regulações no processo cognitivo é a busca de um equilíbrio maior e mais estável (equilibração majorante) ou, ainda, dar estabilidade às operações (ou ações) acrescendo-as de novos elementos que permitam reforçá-las e diminuindo a assimetria entre as afirmações e as negações. Essa assimetria, segundo Piaget, compromete o equilíbrio entre o sujeito e os objetos, entre os subsistemas, bem como entre o sistema total e suas partes. Isso porque, embora exista uma correspondência óbvia entre as afirmações e as negações, estas últimas não se estabelecem senão após laboriosa construção do sujeito. Nesse contexto, as construções novas estão inseridas em processos de reequilíbrio: seja para remediar inconsistências ou limitações das construções anteriores, seja como elemento do processo das diferenciações (internas) ou integrações (parte-todo). Ainda assim, toda construção nova comporta em si mesma algumas regulações que vem a ser as correções dos meios em relação ao novo objetivo perseguido (Piaget, 1975/1976).

Para Piaget, um conceito resulta de transformações dos sistemas de significação do sujeito, num processo continuado, e não pré-determinado, de atribuições via regulações e coordenações sucessivas, transformações de seus sistemas lógicos, ativadas por desequilíbrios nesses sistemas. Portanto, as palavras que colocamos nas caixas dos mapas conceituais (em geral um substantivo) não são necessariamente, na perspectiva do sujeito, os conceitos. Embora tais palavras possam representá-los, são as relações construídas que os delimitam, no exercício de atribuição de significados somente alcançado por complexas atividades de coordenação de suas interações com objetos, em determinados contextos.

Resulta, portanto, que todo novo conceito é precedido por etapas de assimilações anteriores – e consequentes acomodações – que se estabelecem desde os níveis mais elementares das ações do sujeito até o estágio mais elevado, que resulta na capacidade de realizar as operações sobre formas. As formas são as invariantes (generalizações) do funcionamento do pensamento que permitem que as mesmas transformações possam ser realizadas com elementos (conteúdos) diferentes. Cada etapa integra as anteriores conservando, de um lado, elementos e relações não conflitantes com o estado atual do sistema (no caso de acomodações bem sucedidas) e modificando, por outro lado, aqueles elementos e relações que, por uma necessidade da ação (de seus meios e objetivos) ou das transformações e operações no pensamento, tornarem-se perturbações.

Para o autor, um sistema conceitual, com efeito, é um sistema tal que seus elementos se apóiam inevitavelmente uns nos outros, sendo ao mesmo tempo aberto a todas as trocas com o exterior. Suponhamos, por impossível, a construção de um único conceito A, como ponto de partida de uma classificação, etc. Se for realmente um conceito, opõe-se então já ao conceito não-A, o que constitui, desde o primeiro momento um sistema total e circular. No caso, único real, de um sistema multi-conceitual, é impossível caracterizar algum conceito sem utilizar os outros, num processo que é também necessariamente circular (Piaget, 1967/1996). Nesse sentido, a experiência de construir um mapa conceitual pode claramente ser comparada à constituição de um sistema conceitual, ou seja, não há conceito isolado e, portanto, construir um mapa conceitual implica delimitar atributos (escolher relações) dos conceitos ali envolvidos. Sabemos que, no processo de construção, um mapa conceitual pode ser “indefinidamente” ampliado desde que sejam construídos novos significados em relação aos conceitos escolhidos. Essa construção, portanto, depende do repertório de relações que o sujeito é capaz de construir o que, como já foi dito antes, depende da quantidade e da qualidade das interações desse sujeito com os objetos de conhecimento em questão.

Um sistema conceitual assim caracterizado é comparável a uma estrutura, construto teórico sumamente importante para Piaget. Como afirma Ramozzi-Chiarottino (1988), de acordo com a Epistemologia Genética, a estrutura é condição para todo o conhecimento possível.

Uma das definições mais precisas de estrutura pode ser encontrada na obra Biologia e Conhecimento (Piaget, 1967/1996). Resumidamente, podemos afirmar que uma estrutura (ou, particularmente, a estrutura cognitiva): a) contém elementos e as relações que os ligam sem, contudo, ser possível caracterizar ou definir tais

elementos independentemente das relações; b) pode ser considerada independentemente dos elementos que a compõem, ou seja, abstraindo-se os elementos é possível considerar um sistema de relações ou uma ‘forma’ da estrutura; e c) evolui desde tipos mais elementares até os de ordem elevada sendo que uma estrutura mais elementar torna-se elemento de estruturas de maior ordem. Considera-se, portanto, a existência de uma filiação de estruturas: a) uma estrutura pode ser comparada a outra estrutura se for possível definir um isomorfismo que põe em correspondência biunívoca (um a um) cada um dos seus elementos e, respectivamente, cada relação que os une, de tal forma que o sentido de tais relações sejam preservados; e b) uma estrutura contém setores ou partes chamadas de subestruturas que, dependendo do sistema de relações que as constituem, podem ou não apresentar um isomorfismo em relação a estrutura como um todo.

Como explicar a constituição de um sistema conceitual senão pela construção de estruturas? A abstração do conjunto de relações entre os diferentes conceitos de um sistema conceitual implica, portanto, na delimitação de um novo conceito que, novamente, se insere em um conjunto de relações em um nível superior ao primeiro. É inevitável, portanto, a comparação entre um sistema de relações descritos em um mapa conceitual e a definição piagetiana de estrutura. Não se trata, contudo, de dizer que o mapa conceitual é um expressão direta da estrutura cognitiva mas de que, no processo ativado no momento em que o sujeito faz as escolhas para construir um mapa, pode-se ter elementos que auxiliem na observação da estrutura cognitiva para aquele contexto retratado no mapa.

Piaget (1974/1977) demonstrou que é a tomada de consciência que transforma um esquema de ação em um conceito de tal forma que essa tomada de consciência constitui, na essência, uma conceituação o que implica, na prática, uma reconstrução (das ações, dos objetos etc.) que introduz características novas sob a forma de ligações lógicas. Isso conduz a afirmação de que o conhecimento procede da interação entre o sujeito e o objeto. São as tomadas de consciência sucessivas desse sujeito que oportunizam um conhecimento dos mecanismos centrais (explicativos, causais) das ações que realiza (em oposição aos aspectos periféricos tais como o resultado em si da ação). Solidariamente, é também a tomada de consciência que orienta o conhecimento do sujeito sobre o objeto para suas propriedades intrínsecas opondo-se, portanto, àquelas propriedades periféricas relativas tanto ao objeto como daquelas relativas às ações do sujeito sobre ele. Essa lei de sucessão que leva da periferia para o centro, ou seja, das zonas de adaptação ao objeto para atingir as coordenações internas das ações é o que estabelece a tomada de consciência como mecanismo central que explica a passagem da ação para a conceituação ou seja, uma passagem da assimilação prática (a assimilação de um objeto a um esquema) para uma assimilação através de conceitos. Mais uma vez, se pensarmos em processos iterativos de construção e reconstrução de um mapa conceitual, podemos observar os efeitos das tomadas de consciência do sujeito na restruturação das relações entre os conceitos ou mesmo na escolha de novos conceitos adicionados ao mapa.

Por sua vez, Piaget (1974/1978) também demonstrou que, a partir de um certo nível, essa conceituação influencia as ações do sujeito. Nesse nível o sujeito tem a necessidade de construir coordenações sobre operações precedentes. Assim, é somente através de sucessivas regulações em suas ações que o sujeito atinge seu objetivo inicial. Essas regulações implicam, portanto, uma antecipação de resultados parciais no sentido de que está disponível para o sujeito (ele reconhece a existência de novas possibilidades) fazer escolhas. Há um desenvolvimento que permite, por fim, realizar tais regulações (nesse caso podemos chamá-las de operações) nos objetos do pensamento o que revela, portanto, um predomínio da conceituação sobre a ação e os seus resultados diretos. “Cada nova construção se apóia, em seu ponto de partida, sobre elementos que são retirados dos níveis anteriores por abstrações por reflexões” (Piaget, 1974/1978, p.180). Essa nova aquisição do sujeito permite o prolongamento indefinido de seu poder operacional uma vez que não há mais a limitação do mundo físico e é possível construir operações sobre operações.

O mecanismo explicativo descrito por Piaget para explicar as abstrações necessárias às operações com os objetos do pensamento é chamado de abstração reflexionante. Como se pode esperar, há um desenvolvimento que permite ao sujeito tornar-se capaz de realizar abstrações. A abstração “empírica” (empirique) tira suas informações dos objetos como tais, ou das ações do sujeito sobre suas características materiais; de modo geral, pois, dos observáveis, ao passo que a abstração “reflexionante” (réfléchissante) apóia-se sobre as coordenações das ações do sujeito, podendo estas coordenações, e o próprio processo reflexionante, permanecer inconscientes, ou dar lugar a tomadas de consciência e conceituações variadas. Quando o objeto é modificado pelas ações do sujeito e enriquecido por propriedades tiradas de suas coordenações (p. ex., ao ordenar elementos de um conjunto), a abstração apoiada sobre tais propriedades é chamada “pseudo-empírica” (pseudo-empirique), porque, ao agir sobre o objeto e sobre seus observáveis atuais, como na abstração empírica, as constatações atingem, de fato, os produtos da coordenação das ações do sujeito: trata-se, pois, de um caso particular de abstração reflexionante e, de nenhum modo, de uma decorrência da abstração empírica. Finalmente, chamamos de abstração “refletida” (réfléchie) o resultado de uma abstração reflexionante, assim que se torna consciente e,

isto, independentemente do seu nível. (...) a abstração reflexionante comporta, sempre, dois aspectos inseparáveis: de um lado, “reflexionamento” (réfléchissement), ou seja, a projeção (como através de um refletor) sobre um patamar superior daquilo que foi tirado do patamar inferior (por ex., da ação à representação) e, de outro lado, uma “reflexão” (réflexion), entendida esta como ato mental de reconstrução e reorganização sobre o patamar superior daquilo que foi assim transferido do inferior (Piaget, 1977/1995, p.274).

Em se tratando dos processos de conceituação, acreditamos que a Psicologia e Epistemologia Genética de Jean Piaget, fornece elementos mais consistentes no sentido de possibilitar uma interpretação das produções de uma criança ou jovem na escola que permita um acompanhamento de suas aprendizagens. Para a Epistemologia Genética, o problema do desenvolvimento dos conhecimentos, ou seja, a passagem de um conhecimento “menos bom” ou mais pobre para um saber mais rico (em compreensão e em extensão) passa pelo desenvolvimento das estruturas subjacentes a tais conhecimentos (Piaget 1970/1990). Em toda a sua obra, ele constrói argumentos em defesa da idéia de que o desenvolvimento das estruturas de pensamento não é dado a priori, ou seja, ele resulta, como afirmado no início desse artigo, de uma conquista do sujeito enquanto agente em um meio que lhe oferece conteúdo para ser transformado e, ao mesmo tempo, apresenta resistência a determinadas transformações.

2 O modelo lógico de Piaget para a compreensão do funcionamento do pensamento formal

“A idéia central é a de que a formalização não é um estado, mas um processo, e que ela se apóia, consequentemente, em estruturas que se elaboram segundo níveis” (Piaget, 1971/1976, p. XVII). É com essa disposição que Piaget apresenta seu Ensaio de Lógica Operatória (Piaget, 1971/1976). Nossa intenção, nessa seção, é a de organizar e expor um conjunto de definições e operações da lógica formal (de Boole) compiladas por Piaget com o propósito de estabelecer um modelo de interpretação das estruturas que, segundo ele, caracterizam o tipo de pensamento de ordem superior: o pensamento formal.

2.1 Proposições classes e relações e operações entre proposições

Uma proposição é um enunciado passível de qualificação. Ou seja, uma proposição deve ter uma significação, para que possa ser avaliada como verdadeiro ou falso. O enunciado “este cravo é vermelho” é uma proposição lógica por possuir essa característica. Chamemos o exemplo acima de p ; nesse caso, a sua forma negativa, seria “este cravo não é vermelho”, o que também é uma proposição lógica verificável. A verdade ou falsidade de ambas é verificável, qualidade que as define.

Segundo Piaget (1971/1976), o conhecimento evolui de forma a se estruturar em um sistema de proposições, inter-dependente e dinâmico. Nos níveis superiores, o raciocínio se daria, portanto, através de operações lógicas que organizam esse sistema. A partir de reflexão sobre experiências concretas, por exemplo, o indivíduo pode perceber inconsistências nas relações que estabeleceu anteriormente, e modificá-las. De acordo com Piaget (1971/1976, p. 32) pode-se então conceber um conjunto de operações que consiste em compor uma proposição com uma outra, ou com ela mesma, de modo a obter uma nova proposição bem determinada quanto a seu valor de verdade. Por exemplo, a condicional ‘se p então q ’ será uma nova proposição falsa apenas no caso em que p é verdadeira e q falsa; a conjunção ‘ p e q ’ será uma nova proposição verdadeira apenas se ambas forem verdadeiras.

A essas operações, Piaget dá o nome de operações interproposicionais. Existem, ainda, operações que se dão dentro de uma proposição: um conjunto de operações como consistindo em transformar as proposições, por decomposição de cada uma dentre elas em seus elementos e por modificação dos elementos assim decompostos. Por exemplo, numa proposição tal como ‘este cravo é vermelho’, pode-se substituir ‘este cravo’ por outros termos (‘esta bandeira’, ‘todos os cravos’, etc.) ou substituir ‘vermelho’ por outros predicados (‘amarelo’, ‘preto’, etc.), ou ainda, modificar a relação ‘é’ (‘aquele cravo ultrapassa em beleza este’, etc.). Tais são as operações intraproposicionais (Piaget, 1971/1976, p. 32-33).

Com base nesse ponto de vista, de que nosso pensamento se estrutura em um sistema de relações lógicas, Piaget afirma: uma proposição p é verdadeira ou falsa, e é exclusivamente como tal que ela intervém no cálculo das proposições, quer dizer, na lógica das operações interproposicionais. [...] Mas, um termo determinado de uma proposição pode ser substituído por um termo qualquer: a proposição ‘este cravo é vermelho’ tornar-se-á assim ‘ x_1 é vermelho’ e, se designarmos o fato de ser vermelho por a , escreveremos esta proposição ax_1 . Quanto à expressão ax , quer dizer ‘ x é vermelho’, não podemos afirmar que seja verdadeira ou falsa. Tal enunciado nem sempre é verdadeiro, já que certos termos determinados x_1 e x_2 , que podemos colocar no lugar de x , não são vermelhos: as proposições ax_1 e ax_2 são então falsas. Mas o enunciado ax também não é sempre falso: ele não é

pois, por ele mesmo, nem verdadeiro nem falso e, portanto, não constitui mais uma proposição, já que o caráter essencial de uma proposição é o de ser verdadeira ou falsa. Nós a chamaremos, como Russell, de 'função proposicional', designando pelo nome de 'argumento' o termo x e considerando a como a própria função. [...] Tomando a variável x seus valores de um conjunto dado, pode-se ainda transformar a função proposicional ax em uma proposição (verdadeira ou falsa) de duas maneiras. Pode-se afirmar, com ou sem razão, que todos os x gozam da propriedade a , [...] ou que um x pelo menos goza da propriedade. [...] As noções de 'todos', 'algum' e 'nenhum', ligados pela silogística à teoria das proposições, exprimem-se assim em termos de funções proposicionais pelas palavras 'todos', 'algum (uns)', 'nenhum' ou ainda 'sempre', 'às vezes', 'jamais'. Ora, exprimindo essas noções essencialmente uma estrutura de encaixe de classes, percebe-se o parentesco entre a noção de função proposicional e a de classe lógica. A uma função proposicional ax , pode-se associar uma classe, a dos elementos que a satisfazem, [...] classe que eventualmente pode ser vazia. Reciprocamente, cada classe pode ser definida por qualquer função proposicional que será verdadeira para os membros da classe e falsa para os membros da classe complementar. (Piaget, 1971/1976, p. 45-46)

As relações, mencionadas anteriormente, estão diretamente relacionadas às classes. Se, por exemplo, na função ax , em que a seja "é redondo", x estiver representado por "bola", x é uma classe; representa um objeto que atribui à função proposicional um valor de verdade. No entanto, se considerarmos axy , em que a seja "em comparação" e y seja, por exemplo, "um cubo", temos uma relação, que qualifica as classes. Nas palavras de Piaget, "uma relação é o que caracteriza um termo por intermédio de outro" (Piaget, 1971/1976, p. 52).

Alguns elementos de uma proposição podem ser substituídos, sem que isso prejudique a estrutura de uma proposição. Em uma função ax , em que a é "de madeira", x pode se referir a "árvore", "mesa", "cadeira", etc., conservando para a função ax o seu valor de verdade. Essa operação é chamada de "substituição simples" por Piaget, que a entende como uma expressão da relação de equivalência entre classes.

Para Piaget, o sujeito efetivamente realiza essa operação no cotidiano: se uma ação, que se refere a um pedaço de madeira x_1 , é repetida em outros objetos que poderão ser igualmente cortados, talhados, etc., estes objetos x_2, x_3 , etc. serão então comparados com o primeiro, do ponto de vista do esquema de ação considerada, e é a formalização deste cotejo que constitui a operação lógica elementar da substituição. [...] Uma equivalência qualitativa é, pois, sempre relativa a um certo ponto de vista, expresso pela função considerada: assim x_1 e x_2 podem ser equivalentes, do ponto de vista de uma primeira função, sem o ser do ponto de vista de uma segunda (Piaget, 1971/1976, p. 75).

Tem-se, assim, que as classes estão relacionadasumas às outras através de suas propriedades. Piaget descreve, para fins de demonstração, duas operações relacionadas a esse princípio: a união e a subtração. Se pensarmos em B como a classe dos objetos combustíveis, teremos que a classe A (objetos de madeira, por exemplo) está contida em B . No entanto, B também corresponde a outros tipos de objetos, que podem ser obtidos através da subtração $B - A = A'$. Este resultado, o complementar de A' , pode ser entendido como "combustíveis, além dos objetos de madeira" que, somado a A , resulta em B . Esse sistema permite, ainda, que se introduza sucessivas relações, hierárquicas ou não.

Sendo assim, é possível perceber que toda classe é passível de ser inserida em um sistema. Piaget dá a essa qualidade o nome de "classificação", e a define como "uma primeira estrutura operatória de conjunto", ou "o sistema formado por um encaixe hierárquico de classes elementares disjuntas" (Piaget, 1971/1976, p. 79).

O intuito dessa descrição do modelo lógico é fornecer elementos para a construção de critérios de observação das relações entre conceitos expressos em um mapa conceitual. Não faremos aqui a descrição explícita de critérios mas, poderemos observar que, a partir de um olhar sobre as operações inter e intraproposicionais, temos elementos para classificar em termos qualitativos a complexidade das relações estabelecidas em um mapa conceitual bem como acompanhar as modificações dessas relações de forma ordenada com possíveis aplicações nos diversos usos dos mapas conceituais na educação.

2.2 As operações interproposicionais

Piaget trata em profundidade das relações entre as proposições, ou seja, as operações interproposicionais: enquanto as operações intraproposicionais consistem em combinar entre si os elementos decompostos de uma proposição, as operações interproposicionais deixam de analisar as proposições p, q , etc. Para considerar apenas sua verdade ou sua falsidade e compô-las como elementos de um novo sistema. A lógica das proposições constitui, portanto, um cálculo autônomo, dependendo apenas da forma das combinações interproposicionais e

negligenciando completamente o conteúdo intraproposicional de cada um dos elementos combinados. Como tal, o cálculo das proposições obedece às suas regras próprias. (Piaget, 1971/1976, p. 205)

A compreensão das operações formais que envolvem as proposições, assim como descritas no modelo piagetiano, oportunizam uma observação das ações (ou explicações) de um indivíduo de forma a reunir evidências que caracterizem tanto os sistemas de transformações de que dispõe para continuamente interagir com os objetos do conhecimento quanto do desenvolvimento das estruturas que tratam organizar esses sistemas.

Metodologicamente, contudo, essa não é uma tarefa trivial. Piaget (Inhelder & Piaget, 1971/1976), a respeito da experiência de colocar em fórmulas lógicas as afirmações sucessivas de um determinado sujeito e verificar quando e como o mesmo utiliza as operações proposicionais, conclui: (a) é quase impossível diante de um enunciado isolado qualquer, decidir se o sujeito faz uso das operações proposicionais ou, ainda, se o faz, que operações ele realizou; (b) é inútil procurar um critério exclusivamente verbal ou lingüístico (por exemplo ‘se...então’ ou ainda as conjunções ou disjunções ‘e’, ‘ou’ etc) para classificar os tipos de operações; e (c) na grande maioria dos casos, a linguagem permanece implícita e o sujeito não isola ou expressa as minúcias de suas inferências, ou seja, no conjunto, a linguagem não traduz senão de maneira muito aproximada a estrutura real do pensamento do sujeito.

Piaget afirma, enfim, que o melhor método a ser utilizado para acompanhar as operações proposicionais consiste em analisar todo o conjunto de enunciados do sujeito e, em especial, suas explicações e justificativas. Assim, são os julgamentos expressos pelo indivíduo que configuram o objeto de análise para o observador. Quais seriam, portanto, as evidências capazes de caracterizar o nível de pensamento formal (o que implica, portanto, na possibilidade de realizar operações proposicionais)? Para Inhelder & Piaget (1971/1976, p.210) se um sujeito consegue produzir interpretações (relativas às provas utilizadas nos experimentos realizados) como resultado de várias combinações possíveis, o que permitiria inferir que verifica suas hipóteses através das respectivas consequências, pode-se afirmar que está realizando operações proposicionais. Está aí, portanto, um possível modelo de interpretação para o acompanhamento dos processos de conceituação que envolvem as operações formais. A construção de um mapa conceitual, em parte, supera a dificuldade apontada no que se refere a expressar os enunciados dos sujeitos na forma de proposições (lógicas). Em trabalhos anteriormente apresentados (Dutra, 2006) propusemos o uso das operações interproposicionais como critério para o acompanhamento de processos de conceituação fazendo uso dos mapas conceituais.

3 As implicações significantes

Segundo a interpretação de Rolando Garcia, a respeito dos estudos apresentados na obra Hacia uma Lógica de Significaciones (Piaget & Garcia, 1987/1989), existe uma lógica das significações que precede a lógica formal dos enunciados. Nessa obra, Piaget demonstra que há uma formação precoce daquele conjunto de operações descritas na lógica formal (tais como as interseções, incompatibilidades etc.) que ocorrem muito antes no plano das ações e não somente no dos enunciados. Para Piaget, desde os níveis mais elementares, o conhecimento envolve sempre uma dimensão inferencial, o que implica dizer que desde os níveis mais elementares de pensamento há implicações entre significações. Piaget chama de implicação significante A->B se ao menos uma significação de B está englobada em alguma de A e se essa significação é transitiva, o que equivale dizer que se uma significação de C está englobada na de B está portanto também na de A.

Tais significações resultam de uma assimilação dos objetos a partir dos esquemas (nesse contexto entendidos como aquilo que pode ser repetido e generalizável em uma ação) de tal maneira que as propriedades não são observáveis “puros” uma vez que constituem, sempre, uma interpretação dos “dados” por parte do sujeito. Uma significação é também aquilo que se pode dizer dos objetos (como uma descrição de suas propriedades) ou, ainda, aquilo que se pode pensar deles (classificá-los, estabelecer algum tipo de relação etc.). No que diz respeito às ações, suas significações se definem por aquilo a que se chega através delas, ou seja, o conjunto de transformações que tais ações produzem nos objetos ou nas situações as quais elas se referem. Para Piaget todas as significações implicam em atividade do sujeito. Se há, portanto, uma implicação de ações (equivalentes, portanto, àquelas descritas nas relações entre os enunciados) deve existir implicações entre suas significações e é esse, portanto, o “berço” da lógica operatória já que, muito antes da linguagem ou das representações expressas há inferências do sujeito que produzem coordenações entre as ações e sua progressiva passagem a composições antecipadas. Conclui-se, portanto, que as ações, sejam elas elementares ou de ordem superior (operações), não podem existir nem funcionar independentes umas das outras.

Estão presentes na obra citada, investigações que mostram um evolução de três tipos de inferências que caracterizam três níveis de desenvolvimento marcadamente distintos. Correlativamente, evoluem também as implicações significantes. O mapa conceitual da Figura 3 mostra, segundo o modelo piagetiano, uma distinção evolutiva dos níveis de implicação significante.

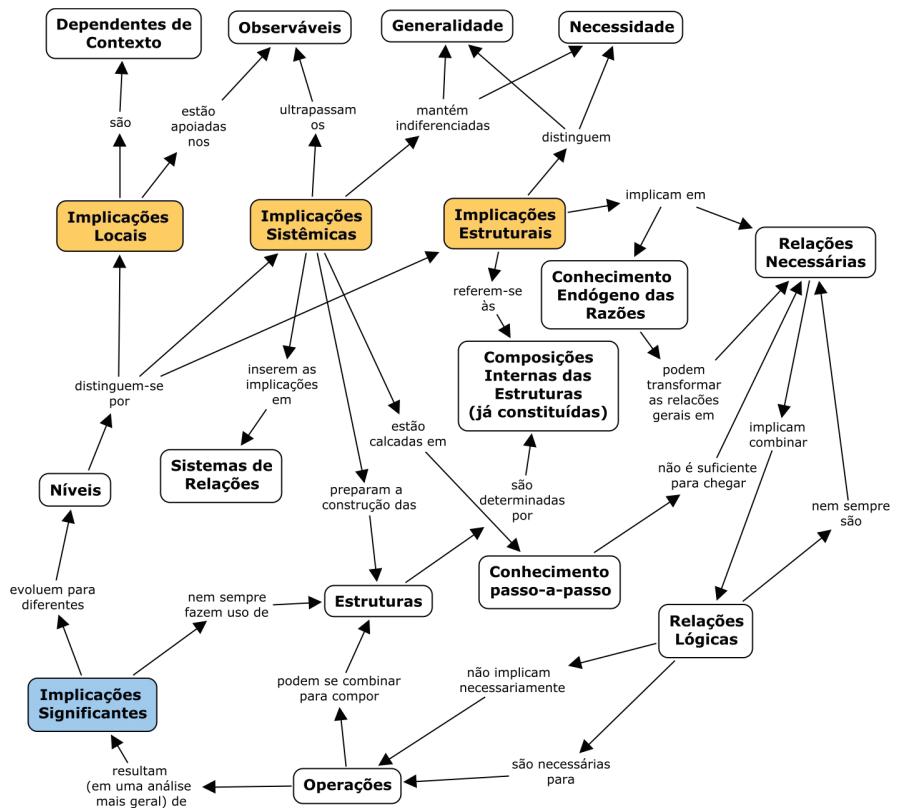


Figura 1. Mapa conceitual sobre as implicações significantes

Esses níveis resultam do desenvolvimento de estruturas que permitem ao sujeito, a partir de um longo processo de construção de relações lógicas elaborado em função das situações em que se vê confrontado, expandir sua compreensão sobre os objetos do conhecimento. Desta forma, Garcia, apoiado nos estudos deixados por Piaget, ao afirmar que há uma Lógica das Significações que precede a Lógica Formal, não contradiz o modelo piagetiano explicitado nas obras que tratam da lógica operatória (Piaget, 1971/1976; Inhelder & Piaget, 1971/1976). O que ocorre é que as operações formais estão suficientemente diferenciadas para permitir a sua combinação em estruturas de conjunto. No caso das implicações significantes, é possível observar, nos níveis elementares, as mesmas operações formais em ações realizadas em contextos muito particulares sem, contudo, serem necessariamente generalizáveis ou aplicáveis em outros contextos. Isso é equivalente a dizer que, consideradas separadamente em seu próprio contexto de significações, tais operações são isomorfas às dezesseis operações binárias da lógica proposicional. O fato é que, ainda que essas relações iniciais sejam apenas “fragmentos” de estruturas, elas já dão a ver um desenvolvimento cognitivo que, diferentemente de outras posições epistemológicas, não resultam de uma transmissão por “blocos” de conhecimento.

Levando em consideração a comparação que estamos construindo, para o caso da construção de mapas conceituais, quando estamos escolhendo uma relação entre dois conceitos (expressa por uma frase de ligação) estamos realizando, em última análise (mais geral), uma implicação significante. Também as implicações significantes, em suas ordens locais, sistêmicas e estruturais, fornecem elementos para a classificação de mapas conceituais ou setores de relações neles expressas com aplicações possíveis na educação (Dutra et al, 2006).

4 Conclusões provisórias

Em trabalhos anteriores (Dutra et al, 2006) já construímos argumentos para sustentar a afirmação de que as modificações nas frases de ligação em um mapa conceitual são indicativas de uma construção conceitual, ou seja, a adição de novos conceitos e frases de ligação bem como as modificações das ligações existentes exigem

tomadas de consciência do sujeito para explicitar as relações entre os elementos constituintes das construções em forma de mapa conceitual.

Assim, o conhecimento a respeito dos mecanismos relativos aos processos de conceituação, à lógica do pensamento formal e as implicações significantes, construtos da teoria piagetiana, fornecem elementos para a análise dos mapas conceituais sob uma nova ótica, com diversas aplicações possíveis para a psicologia cognitiva e a educação.

Espera-se que as bases aqui descritas possam inspirar novas pesquisas e aplicações da teoria piagetiana para os mapas conceituais, ampliando os horizontes teórico-metodológicos construídos até o momento pela comunidade de pesquisadores que tem, a cada dois anos, construído avanços significativos para essa ferramenta.

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COOPERATIVE TEACHING, CONCEPT MAPS AND CREATION OF KNOWLEDGE PORTFOLIO FOR SCHOOL SUCCESS

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Abstract. The transmissive school, on the spur of the digital culture, is in deep crisis. The teachers, left to themselves, feel lost in contact with the *digital natives* and they can not change, fluctuating between innovation and adaptation, pegged to *the traditional*, with the certainty of *having the truth*. Therefore, there is the necessity of a more participatory school that can be inclusive, especially in situations of diffused school dropping out. In such a situation, the transformation of the teachers' role is essential, proposed especially (in the experience that is illustrated) with the work in teams to build concept maps (expressions of the different activities) also to make the structure of the digital portfolio.

Keywords: Transmissive school, Cooperative teaching, Dropping out, Knowledge portfolio, School Success.

1 Dropouts and school success

The institutional responses to the crisis mentioned above, tend, in general, to a feigned modernization: it is not enough the use of new technologies (PC, Whiteboard, Tablet, etc...) for a quality school and to change the pedagogical relationship; the use of modern tools is not sufficient to change the substance of the relationship of education, still based on the teacher that transmits and the pupil who has only to receive.

Teachers implement a predominantly transmissive education, focused on the whole class and with a particular attention to taxonomic planning, organized in non-communicating disciplines. That leads to a linear teaching and ignores creativity, motivation, learning style, individual characteristics and the connections between school and what the student already knows. Also all this contributes to school dropouts.

A School that takes account of the Gutenberg Galaxy and the Internet Galaxy uses a cooperative workshop teaching, , which integrates various forms of knowledge, and uses the various available resources, from the perspective of moving from a transmissive conception of knowledge to a laboratory teaching, permeated by the digital culture.

Students are able to organize a job more easily, a hypermedia product, if they start by themselves, telling and using a strategy that allows them to feel included, which facilitates the expression of their identity as citizens and people and therefore the integration and acquisition of citizenship. The school dropping out occurs also because there is a mechanism of exclusion cycle.

The spiral > low self-esteem> little confidence> bad performance> negative evaluation> low self-esteem> is a chain which traditional education generally fails to break, but reinforces it, contributing to dissatisfaction with school, before school dropouts and social disintegration in the broadest sense. See Figure 1.

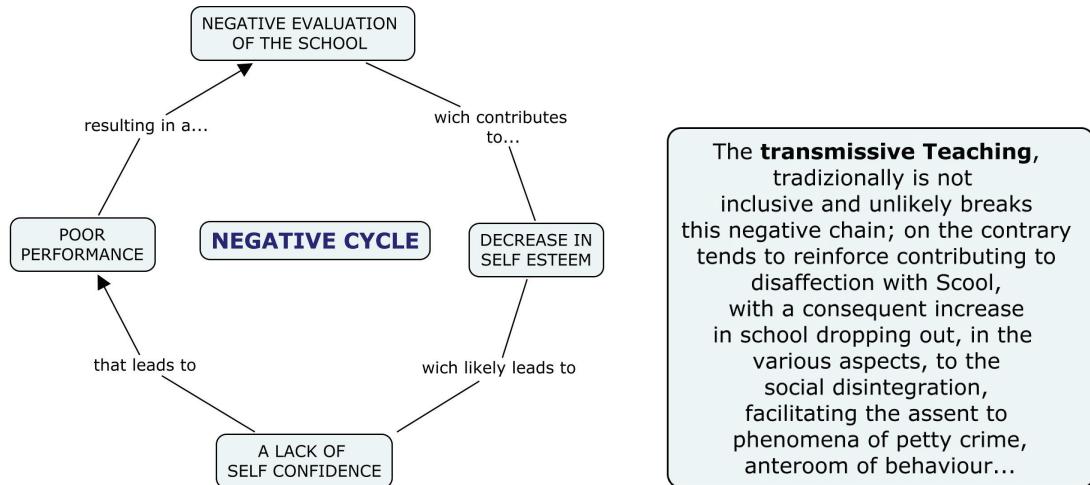


Figure 1: Negative cycle in a transmissive teaching

The positive view of themselves with the enhancement of their own characteristics, which takes place , instead, in the workshop activities, undermines the system and allows to "break" something in this chain, helping to change its direction into the spiral > good performance> positive assessment> growth of self-esteem > confidence > good performance >. See Figure 2.

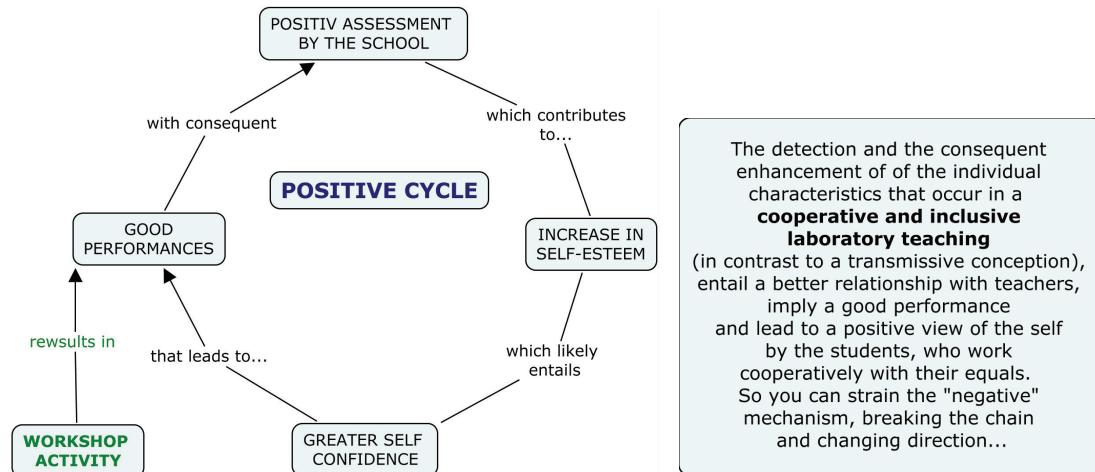


Figure 2: Positive cycle in a laboratory teaching

2 Cooperative teaching and teachers' training

School teaching has known, in these last years, a constant renewal, which implies to revise traditional methods in school, but it has not been sufficient to determine the growth of quality and quantity of learning. A mainly explanatory teaching, focused on class groups, with a particular attention to taxonomic planning, organized in non-communicating disciplines, leads to a linear teaching and ignores creativity, motivation, learning style, individual characteristics and the connections between school learning and what the student already knows. Today, in the digital era, the process of teaching/learning must meet the demands of the knowledge society and, at the same time, it must be more exciting and engaging for the students. Furthermore, in the society of the third millennium, it is even more imperative to change how to "make ? school", in order to promote equalities and opportunities for all together and everybody in particular, and to focus primarily on the last, that is those who have more need for remedial teaching for better social integration.

It is not enough, although necessary, to change the instruments or merely adopt the latest theory to determine a real change in a direction more useful to the collective growth, but we can say that the question is how to build a *different school*.

Therefore, the specific aims of a *different school* are:

- to transform the role of the teacher, from a transmitter to a provoker and a coordinator;

- to enable new organizations of the school environment;
- to make the school, with its contents and tools, more familiar to children, the digital natives;
- to promote communication;
- to promote learning rather than teaching

Using as methods and tools:

- Brainstorming - Different learning styles and multiple kinds of intelligence
- Concept maps
- Cooperative learning
- Use of ICT and digital culture
- Search on the Internet
- Production of multimedia

3 A ministerial project against dropouts, for school success

A series of projects, funded by the European Community through the MIUR (Ministry of Education), are taking place in the southern regions of our country, with the goal of reducing dropping out and promoting educational success. They can be documented also through a digital portfolio and assessments of the skills built during the paths punctually indicated. In the old centre of the city (Napoli), there is a widespread situation of school dropouts, arising, among other things, from:

- Difficulty in keeping students' attention in a long time.
- Suffering to respect the rhythms and the timing of the various school settings.
- Low levels of self-esteem
- Difficulty in the implementation of a process of self-construction of knowledge ("mechanical" use of outlines and algorithms), difficulty in the abstract learning and in the sequence theory - practice;
- Low skills (factor that in turn increases the self-devaluation);
- Total disregard of the informal knowledge by the school;
- The experimental project "I Know, Therefore I Am" has the objective of building a pedagogic-didactic prototype against the school dropouts, for the educational success.

Therefore, a local network between two middle schools and one high school has been constituted, along with some associations operating in the area. The operations were carried out on groups of students at risk of dropping out in the two primary schools and the two junior high school (coordinated with the only senior high school participating in the project) with 5 different paths

In this project, we have tried to go beyond the *transmissivity*, experiencing a cooperative laboratory teaching, with the collaboration of operators of the external associations. A real problem has been to convince teachers, because there is a certain resistance to change from some teachers who see in such a way diminished the importance of their role. The phase of teachers' training was very useful especially to use the concept maps in the different stages, till the creation of the ***knowledge portfolio***. The typical laboratory didactic path is illustrated by the map in Figure 3.

- You start with a brainstorming session to set the arguments (usually interdisciplinary in order to overcome the sectorial feature of the disciplines), to identify conceptual nodes on the map (prepared with a PC) projected on the screen. The teacher helps students to express themselves in order to encourage their participation and take account of prior knowledge;
- You work constituting small cooperative groups (each of which is assigned the branch of the map that most interests them) according to the Multiple kinds of Intelligence (taking into account the diversity of the cognitive styles of the participants), identified by the use of special software ;
- For research and deeper analysis, you use PCs connected to the Internet, dealing with subjects to be developed afterwards in more congenial to the individuals ways of research and communication, and the individual groups organize the presentation of knowledge with maps (free software) and with advanced technologies (PC, LIM, Network Internet, Tablet, etc.) ;

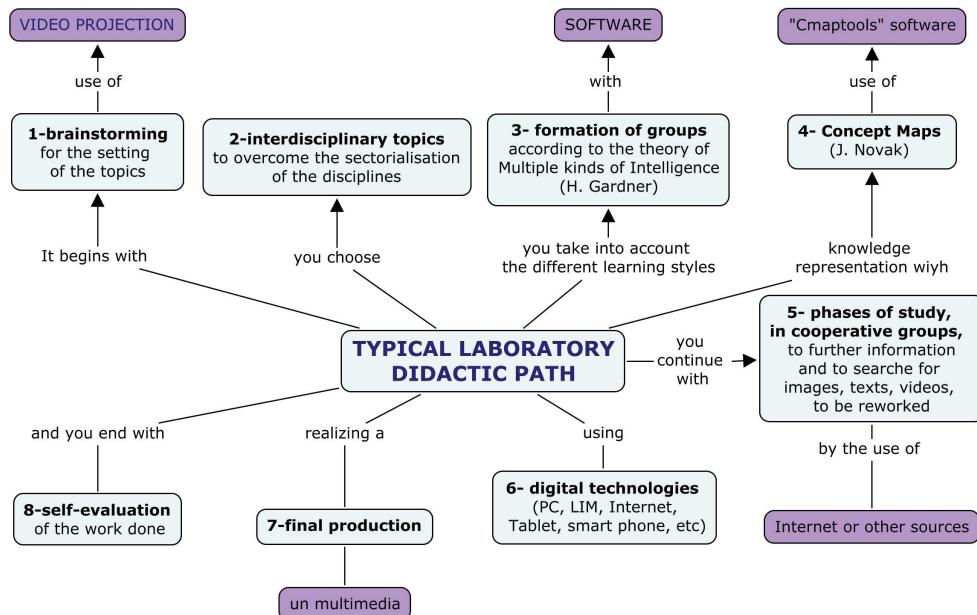


Figure 3: The typical laboratory didactic path

The teacher is not longer a simple transmitter of knowledge, but becomes a provoker of interests, a proofreader, a trainer, a definer - illustrator of a path, a starting point for an individual and collective deepening, which constitutes a new subject for students.

The supply of materials to be studied is not prearranged, but it turns into flexible and personalized cognitive paths; students not only use the codified knowledge of the textbook, but integrate the knowledge through a variety of tools and sources: the Internet , the teacher, films , experts, books, etc.

The experience ends producing a multimedia and the self-assessment of your work (product and path).

The results are interesting for the use of a single methodology at different levels of school (including universities), and the reproducibility of the experience in different contexts

An interesting teamwork between the trainers and the teachers, tutors of the project, was done in the project, to identify the specific contents and the methodological framework for the individual actions, using concept maps.

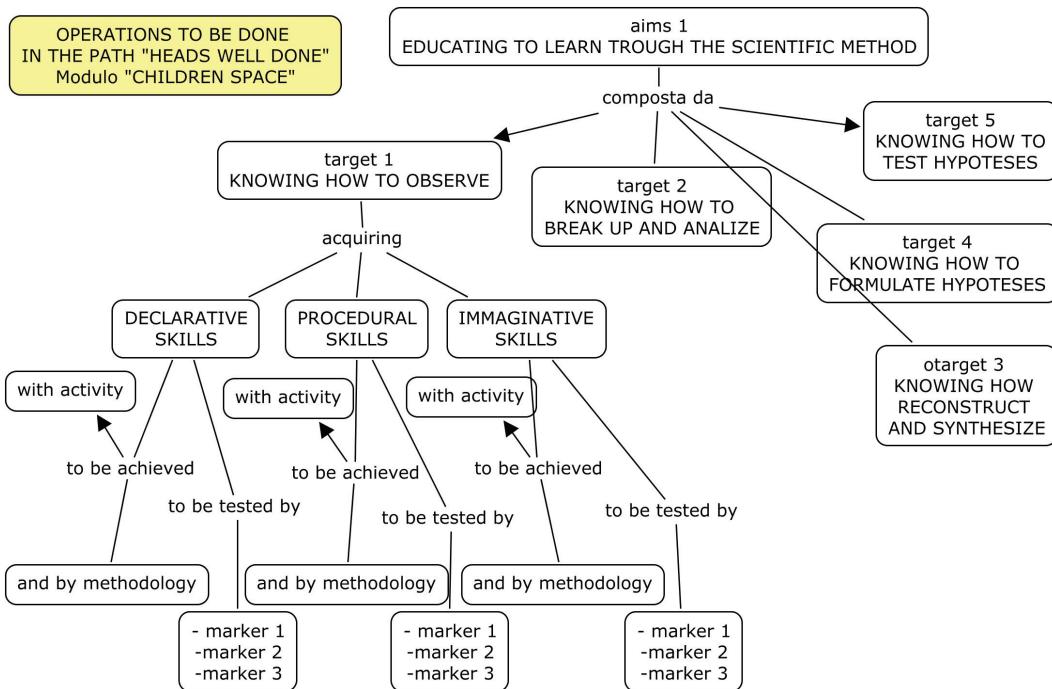


Figure 4: Specific teaching action "heads well done".

The following figure 4 shows examples of specific teaching actions.

4 The Collaborative construction of the portfolio with concept maps.

As a part of the learning by skills, the European Community has identified in the Portfolio the skills a suitable instrument for a more coherent with the proposed methodology evaluation. Therefore, we have thought to adopt, within the project, an example of experimental *Portfolio*, with the goal of "transfer" it to the morning curricular courses.

For the student the *Portfolio* answers to the questions: What are my characteristics? What are my points of strength? How do I show them? How can I improve?

The *Portfolio* documents the skills of the single student, not only through the achievement tests, but also through the products manufactured and the "narratives" about the gradual improvements and achievements, helping: **to reflect** on his own learning process (metacognitive function, to give them a meaning); **to improve** self-esteem and help build a positive identity (empowerment function); **to self-evaluate**, **in** comparison with the results achieved, allowing to better understand himself; **to orient** himself among the choices of study/work.

The *Portfolio* is represented by the map in Figure 5; it has been developed in collaboration between the project team and the tutor teachers. This step is very important because the construction through the concept map has allowed all tutor teachers to experience the validity and the easiness with which we can achieve the digital *Portfolio*, of which they convinced themselves during the process of realization of the same *Portfolio*.

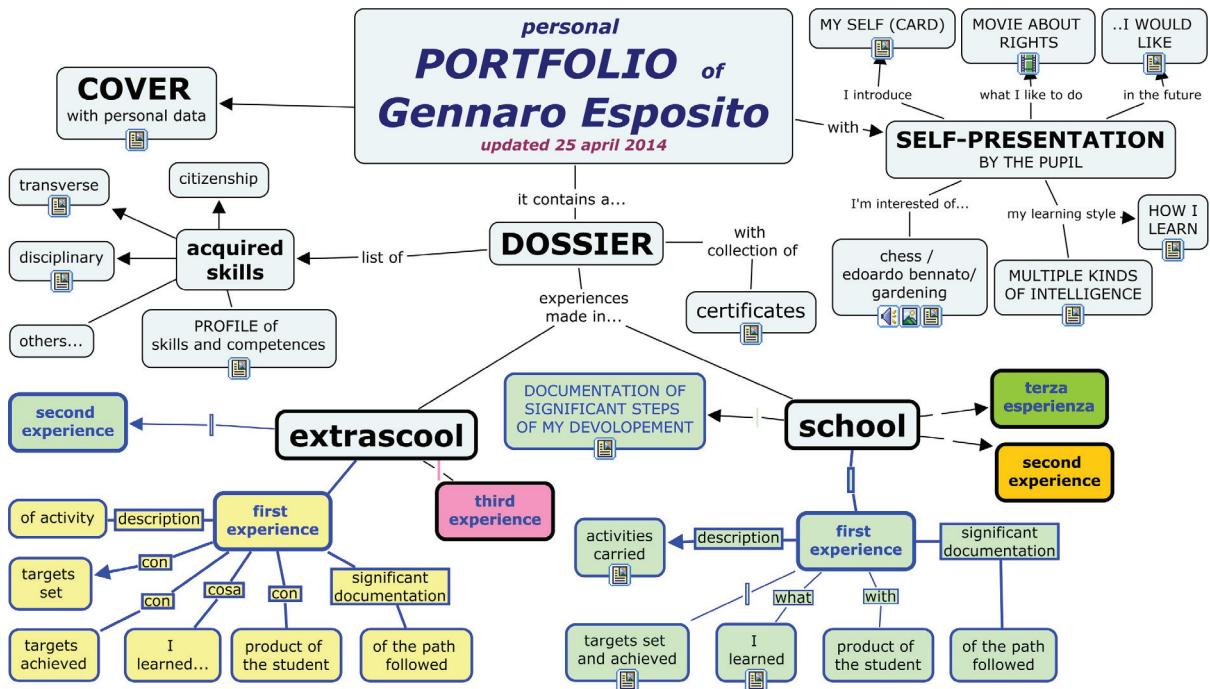


Figure 5: Knowledge Portfolio map

During this period, special meetings are taking place between tutor teachers and students, to realize the individual personalized students' *Portfolio*.

The *Portfolio* contains some personal identification data, a kind of self-presentation, and a dossier of "documentation" multimedia of significant school experiences (and extracurricular), which are updated from time to time.

5 Perspectives

The purpose of the experimental activity, still in course, is to build a prototype training to combat early school leaving; we need to see how the experience of the team work among teachers using a cooperative workshop teaching permeated by digital culture, supported also by the concept maps, can be transferred to the morning curricular courses

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CORPORATE USES FOR CONCEPT MAPS

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Abstract. Corporate world is a complex environment. Large volumes of information from various sources must be addressed under a faster and faster pace in order to make decisions. Business competition, regulations, changing requirements, progressive integration and interdependency between departments and functions are some of the factors contributing to the increasing complexity of daily tasks inside corporations. In this setting, professionals are expected to find effective ways to deal with challenges, often resorting to creatively applying several tools to manage knowledge and solve problems. Concept mapping, due to its flexibility and features, is an appropriate tool for this scenario. Despite its origins in a different, educational setting, concept mapping has unveiled great capabilities for use in corporations. This paper discusses and illustrates some of those possible applications, based on practitioner experience and real world problems, intending to inspire innovative uses for concept mapping.

Keywords: corporate, concept map, application, use.

1 Introduction

During last decades, changes on information, economy and work relations have exponentially increased complexity in the corporate world. This reflects in corresponding increased complexity of contemporary professional tasks, as new abilities are required and several different areas of knowledge need to be correlated. To perform well in such a complex environment, professionals must resort to knowledge management techniques and innovative approaches.

In this context, the use of concept mapping has revealed itself highly suitable. Concept maps, as graphical tools for organizing and representing knowledge (Novak & Cañas, 2008), have emerged from the educational community in the 1970's and still today they seem to find their mainstream in there. However, in the 1990's concept mapping started spreading into the business world as an aid in solving problems in workplace, in a trend designated by Moon et al. (2011) as applied concept mapping.

There are a number of knowledge management methods that can be used to graphically represent knowledge (Buzan & Buzan, 1993; Novak & Cañas, 2008; Village, J. et al., 2013). But among those techniques, concept mapping presents some advantages over others, making it suitable for a variety of applications.

2 Methodology

The main objective of this paper is to illustrate expanded applications for concept mapping in the corporate world, providing examples based on real, daily professional problems. Hence, this work is mostly based on author's practitioner experience in logistics research, shipping process analysis and information system development. Some concept labels (names) have been changed or generalized in order to preserve classified information, yet enough attention has been paid not to turn them into purely theoretical examples. Motivation for this writing came out from the perception stated by Novak & Cañas (2010) that few corporate uses for concept maps have been reported (Dumestre, 2004; Fourie & Westhuizen, 2008; Freeman, 2004; Kyrö & Niskanen, 2008). Thus, this paper aims to fill this gap, in order to contribute to the concept mapping communities worldwide.

All provided concept maps were designed using CmapTools software (Novak & Cañas, 2008). Original styles were changed from colorful to greyscale in order to meet printing requirements.

3 Important Features in Concept Mapping

One of the most important features in a concept map is the focus question, once it keeps the mapping activity oriented towards a clear objective. Enunciating an appropriate focus question is a good starting point for

achieving representative, high quality concept maps. Thus, it is desirable that the focus question remains visible during the entire mapping process, preferably as a guideline in the header of the map, as shown in Figure 1.

Concepts used in the map must be clear, so that their meanings remain explicit and easy to understand. For this reason, Crandall (2006) discourages the use of colors to code meaning in concept maps. Even though, in some cases we see advantages in the use of different colors and styles to categorize or highlight concepts or groups of concepts, as it may help emphasizing hierarchy and keeping point of relevant concepts within the map. Colors and styles may also bring additional properties to concepts, such as variations of status in time, or temporality (as it will be shown ahead in Figure 3). Nevertheless, if any notation is used (be it of color or style), it must be properly captioned to ensure the related meaning is fully understandable and explicit, instead of becoming tacit. Notice an example of captioning for the styles on Figure 1, at the upper left corner. In addition, encompassing the captions within a nested node makes it possible collapsing the whole caption for additional clearance.

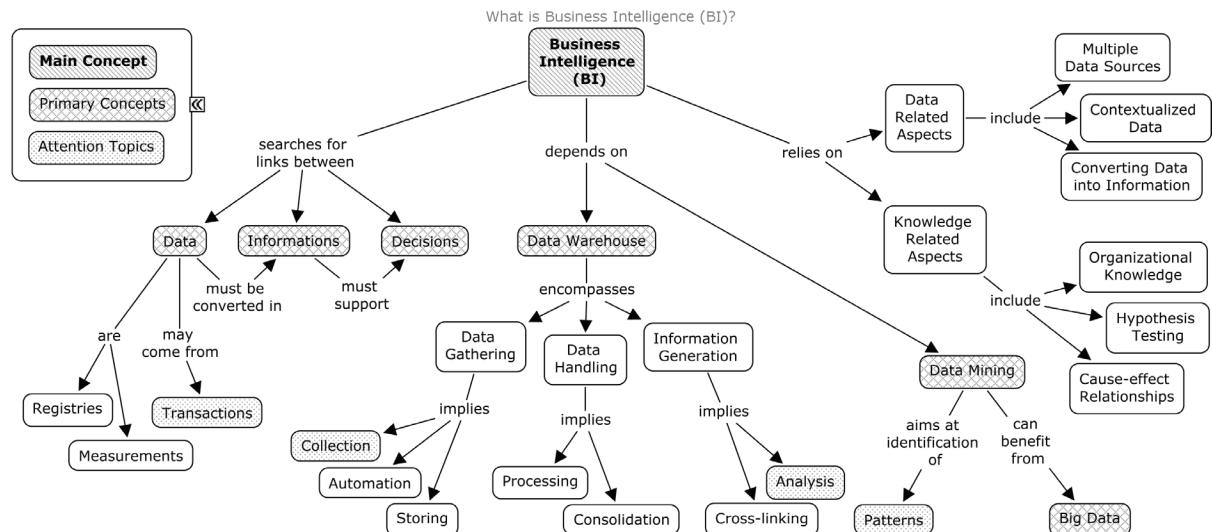


Figure 1. Additional meaning and information can be provided by styles and captions.

Despite the apparent simplicity of the concept map idea, the underlying constructivist theories (Ausubel, 1963; Novak & Cañas, 2008) demonstrate how solid the foundations of this technique are. In this way, a distinguishing principle of concept mapping is the use of linking words to form independent propositions. This structure reinforces meaningfulness, as it allows to clearly explaining relations between concepts. Choosing appropriate linking words while making a map usually allows maximizing the capture and understanding of meanings.

Furthermore, the availability of CmapTools as a software kit for handling and sharing concept maps constitutes a major advantage, granting flexibility in the mapping process.

4 Some Corporate Uses for Concept Maps

Due to their graphical nature and inherent flexibility, concept maps fit a diversity of applications regarding knowledge modeling and problem solving in complex, abstract and fuzzy settings. Some of those possible applications will be presented and illustrated as follows.

4.1 Risk Analysis

Concept maps have turned to be appropriate for risk analysis on complex decisions. The hierarchical structure of the maps allows to group risks under more general concepts (see for instance Figure 2, *Main Risk Areas* caption and respective concepts). Each risk group is related to a risk generating factor, providing explicitness for brainstorming individual risk possibilities associated to each factor. Identifying the individual risks is an important step prior to considering mitigation actions, as well as categorizing risks into a hierarchical structure is beneficial to a correct risk identification.

As risks are interrelated, some cross-links resulting from additional reflections may indicate which risks hold the most critical potentials, allowing better mitigation and contingency planning.

Once decisions or events happen, on the fly information may be logged to the risk map as well. For instance, see *Test Realization and Reporting* concept in Figure 2. Inside this nested node there are other concepts related to the realization, events and results happened during the upgrade pilot test. This is a way to keep track of the status of risks, to enable posterior analysis, to evaluate the quality of planning and to discuss learned lessons.

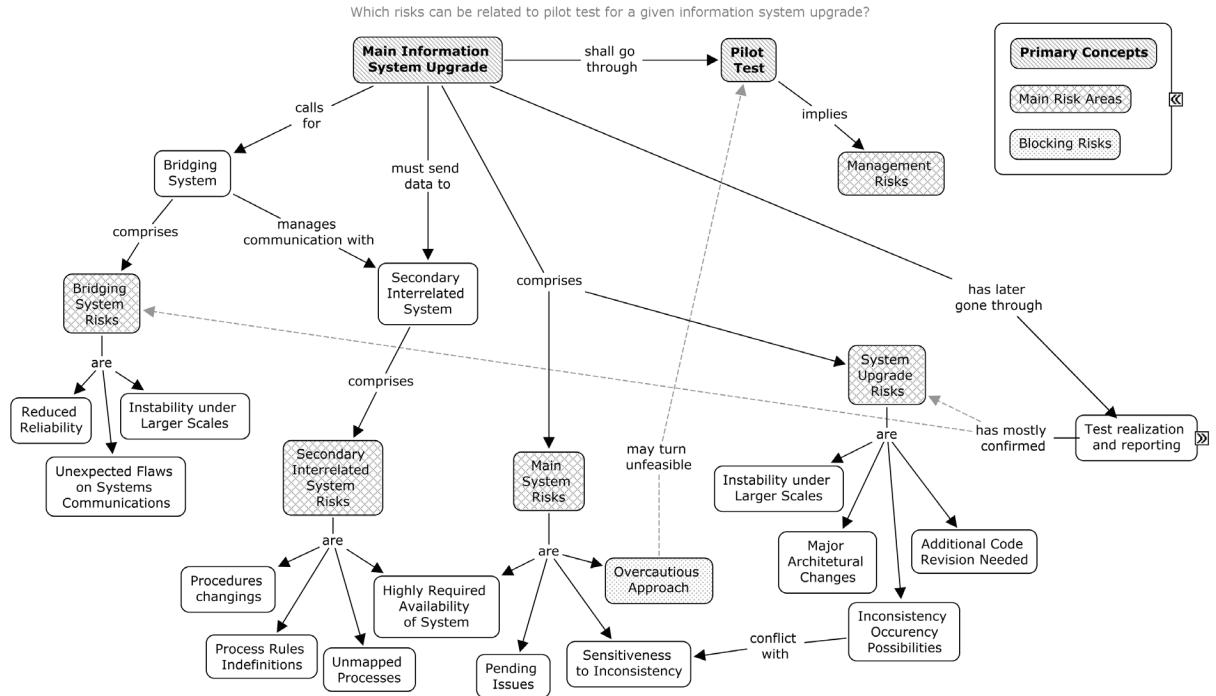


Figure 2. Map used for risk analysis of a system upgrade pilot test.

4.2 Action Planning

In a similar fashion than in previous item (4.1 - *Risk Analysis*), the capabilities of concept maps to group and categorize information into a hierarchical structure may aid well in action planning. As illustrated in Figure 3, a concept map was used to brainstorm, discuss and analyze each related aspect in an initiative to upgrade an information system. Given that the upgrade implied deep architectural changes in the system, a detailed action plan was needed prior to performing the referred upgrade.

An additional, desirable feature in this case is temporality, or the indication of change/progress through time, which is not an usual characteristic of concept maps. Once the planning effort was considered satisfactory and the upgrade process was initiated, the progress of upgrade actions could be indicated in the map by using different styles in association with captions (see captions at upper left corner of Figure 3, where each style indicates a different status). Then, as planned actions took place, the concept map was updated by changing the styles of the concepts. This approach has expanded functionality of the concept map, as it has allowed checking and monitoring process execution.

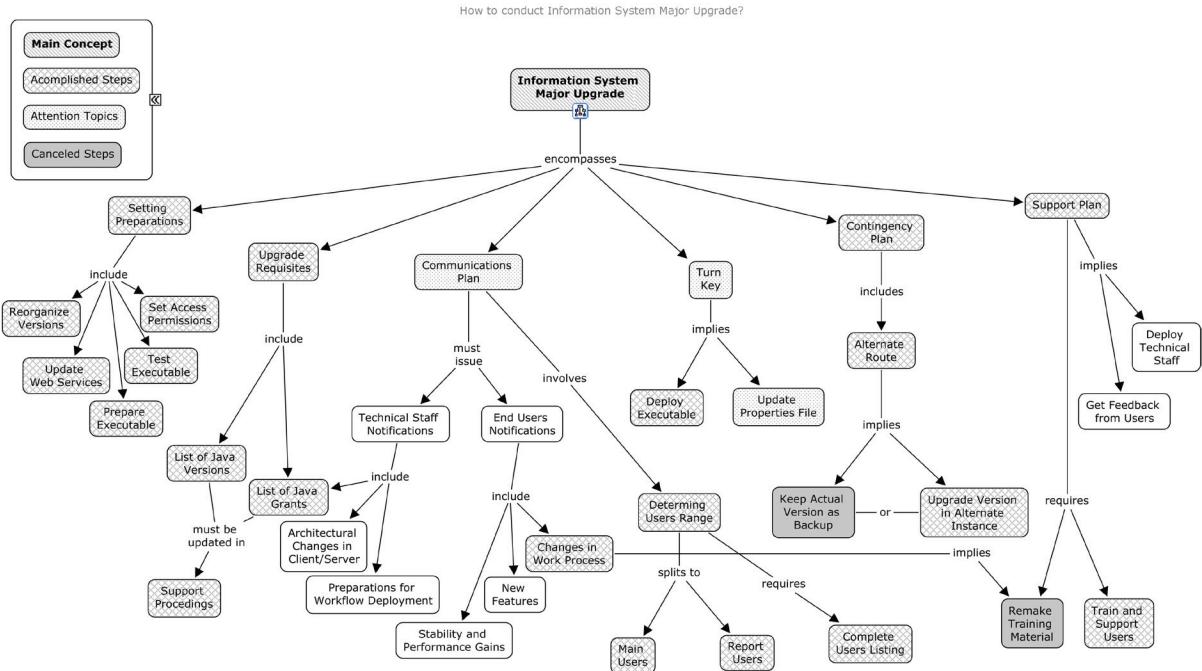


Figure 3. Action plan map, including temporality.

4.3 Training

In regard to training, concept maps may be used in two different ways. One of them is planning the training course, much similar to an action plan encompassing everything that needs to be provided in order to make the training happens. In this case, styles can indicate the status of each step required to organize the event and make it feasible (see Figure 4). The training content itself can be assembled in the same map. In the example in Figure 4, it is hidden under the *Content* node, which derives from the *Guide* concept.

Another way of using the same concept map is to turn it into the own course “book”, presenting and discussing contents aided by the concept map on screen. Considering the hiperlinking capabilities to other media, complementary material can be exposed from the map, while supporting the discussion on main topics. In this situation, a positive side effect is the interest that the concept map itself can draw.

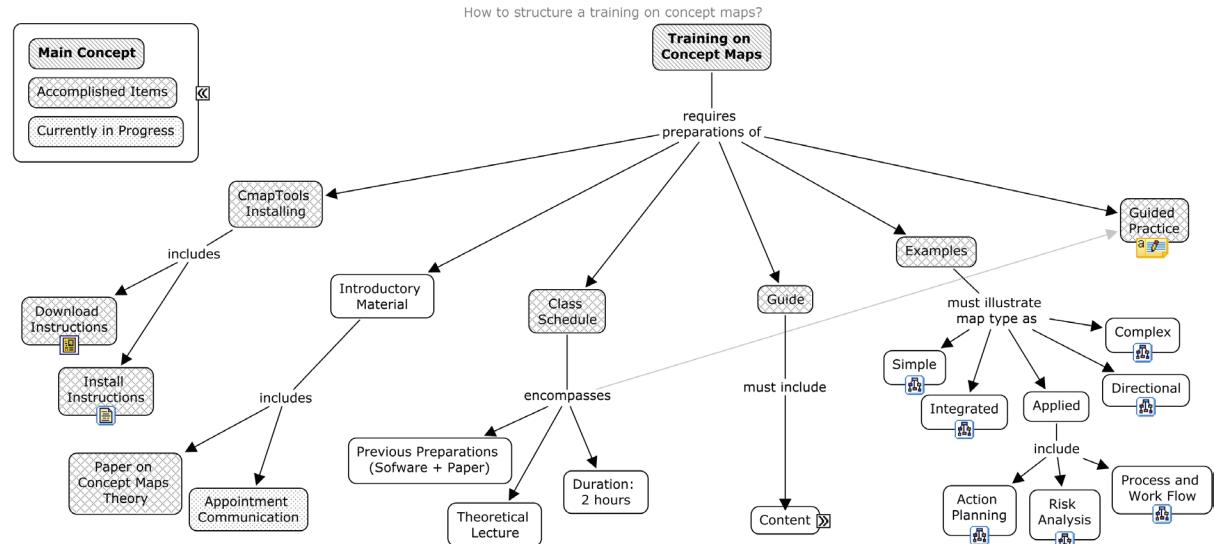


Figure 4. Map including training plan and content about concept maps.

4.4 Process Representing

Although concept mapping is not deliberately meant to be a process modeling technique, it may be used for organizing and structuring information gathered in initial interactions, interviews and field observations.

Several business departments or working groups hold subjective concepts and tacit values merged into their activities, what often requires initial interactions to explore and collect main concepts and their relations, followed by further discussions to refine and validate those concepts/relations and the resulting process arrangement. In this way, concept mapping can be used both as a knowledge elicitation tool and as a process representing tool in a higher level of abstraction.

See for instance Figure 5, where an upper level of transport scheduling process has had its inputs and outputs mapped. Each concept in this representation comprises a large subset of data sources, data itself, links to other processes and areas. Nevertheless, all things the transport scheduler needs to know and to produce are summarized in this process representation. As additional details are raised, they may be registered in other concept maps, which will be linked to this upper level map (as indicated by the map linking symbol at the bottom of the central concept). In the end, a set of concept maps will constitute a knowledge model for the elicited work process.

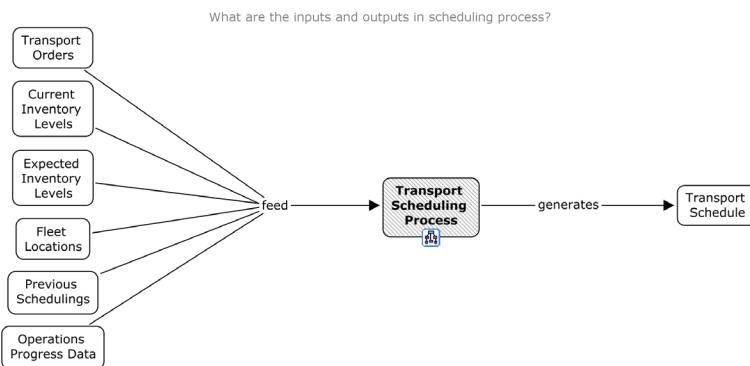


Figure 5. Work process represented by concept map during requirements elicitation.

There are also unusual ways to explore the propositional structure of concept maps (as a set of concepts and propositions). For instance, the concept map framework can be used to represent work flows, where sequential steps can lead to multiple results. Figure 6 depicts how a ship voyage created in a tactical level was unfolded to the operational level, during the implementation of an workflow managing system. This lead to a transition phase where pre-existent registries had automatic approval; while new registries were sent to analysis staff.

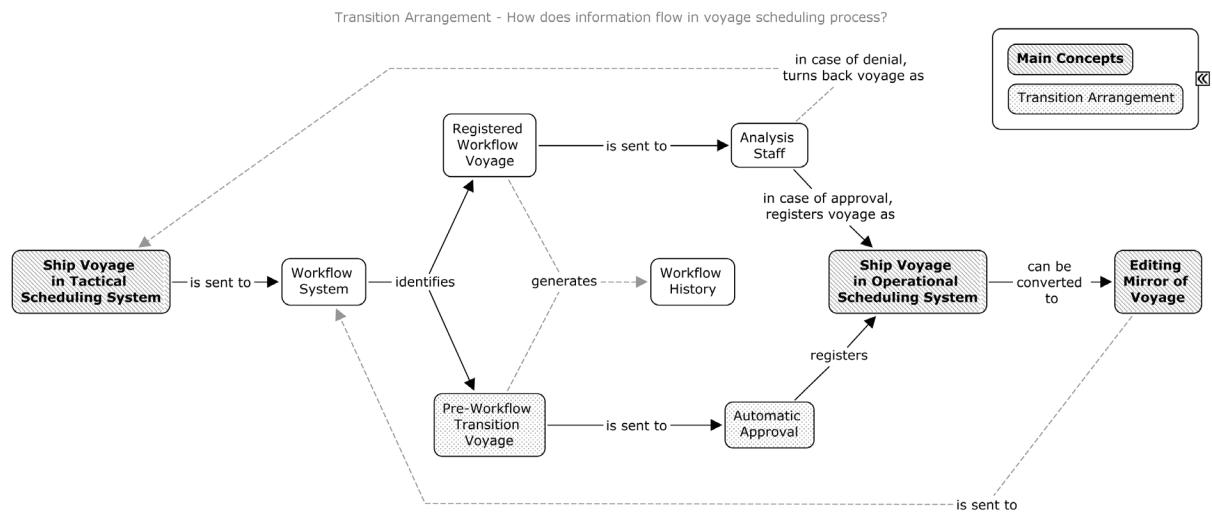


Figure 6. Concepts and propositions used to depict a work flow, in a less usual approach.

4.5 Work Load Balancing

The inherent panoramic capabilities of concept maps may yet be applied to balance the work load of employees, guaranteeing adequate distribution of effort. Expressing and grouping activities into a concept map can be a way

to manage tasks and also to improve communication inside staff. An example for this application is provided in Figure 7, where activities are gathered under mains groups. This feature can be used either for planning as for monitoring, being subject to revision at any time, since it addresses a dynamic situation.

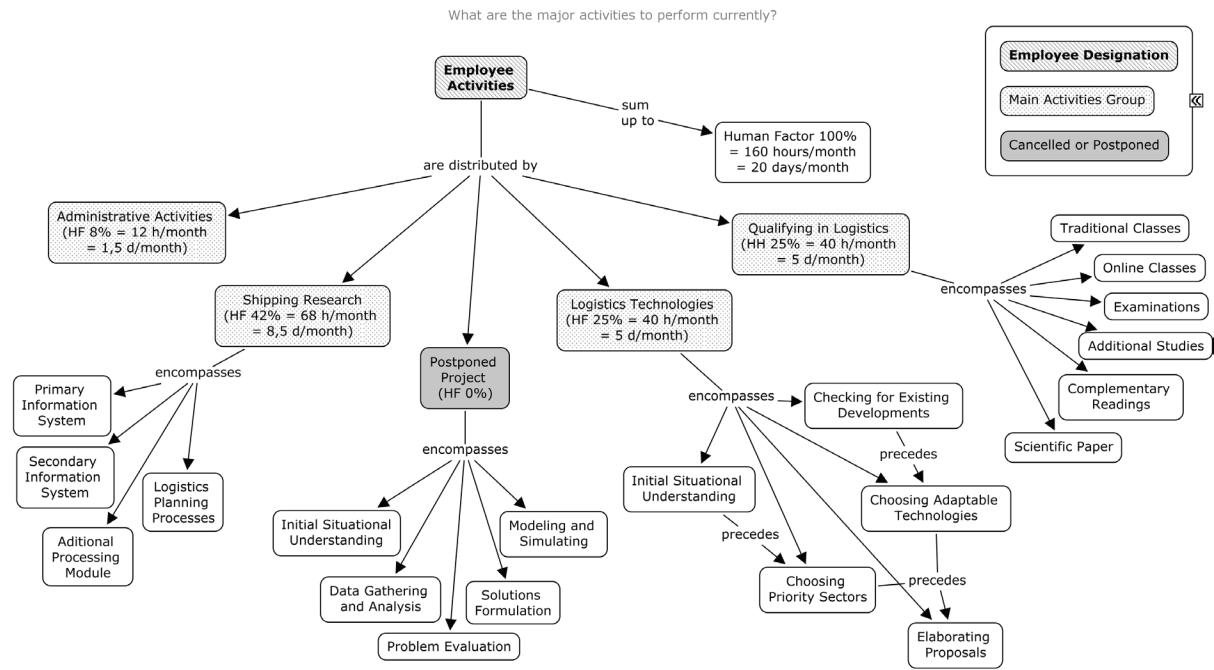


Figure 7. Visualization properties enable map use for work load balancing.

5 Summary

This paper aimed at remarking the feasibility of applied concept mapping in corporations under innovative ways, often different from those usually predicted in educational settings. For this purpose, some particular features of concept maps have been discussed, such as the importance of adequately using focus questions and the use of styles and colors to group and categorize concepts. Several applications for concept maps in corporations have also been presented, illustrated and discussed.

From our experience, the use of concept maps seems to be specially promising for action planning, risk analysis and for the elicitation and understanding of work processes. As those activities are widespread across many kinds of organizations (corporations, government agencies and non-governmental organizations in almost any field of operation), there is a vast potential for the application of concept mapping techniques.

Considering the flexibility of concept maps, and in face of those possible applications (far away from being an exhausting list), it can be stated that concept maps fit corporate uses in several ways, as well as innovative uses must be tried for different approaches and needs.

And surely those innovative approaches must be reported to the community of concept mappers, in order to improve and spread knowledge.

6 Acknowledgements

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DETECCÃO DE INCOERÊNCIAS NO PROCESSO DE AUTORIA DE EXERCÍCOS DE COMUNICAÇÃO ESTRUTURAL POR MEIO DE MAPAS CONCEITUAIS

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Resumo. A Comunicação Estrutural é uma técnica pedagógica cujo objetivo é ajudar na avaliação e no exercício de habilidades intelectuais de pensamento crítico e complexas estruturas conceituais dos aprendizes. A CE é uma técnica pouca usada porque é muito difícil desenvolver conteúdo da forma propugnada por ela. Uma forma de facilitar a autoria de exercícios de comunicação estrutural é fazer uso de mapas conceituais para definir o conteúdo de suas diversas partes. Mesmo assim, de forma idêntica ao que acontece sem o uso de mapas conceituais, o material educacional assim gerado pode apresentar incoerências, como material em duplicidade numa dada parte ou presente numa dada parte e ausente em outra quando deveria estar presente. Com base nos mapas conceituais usados para definir o conteúdo, propõe-se um modelo computacional capaz de identificar, de forma automatizada, as incoerências no decorrer do processo de autoria de exercícios em Comunicação Estrutural. Como resultado, espera-se que, com o uso de mapas conceituais e a detecção de incoerências, a autoria fique mais facilitada e o conteúdo dos exercícios em Comunicação Estrutural mais coerente e sem furos conceituais.

Palavras-chave: Comunicação Estrutural, Mapa Conceitual, Detecção de Incoerências, Autoria de Comunicação Estrutural.

1 Introdução

A Comunicação Estrutural – CE é uma técnica pedagógica que possibilita a simulação do diálogo entre o autor da instrução e o aprendiz durante a execução de uma atividade instrucional formatada com base em suas seções (Egan, 1976), a saber: i) Intenção da atividade instrucional, ii) Apresentação da atividade instrucional, iii) Investigação de Desafios inter-relacionados, iv) Matriz Resposta com possíveis elementos ou conceitos para compor a solução dos desafios ou problemas, v) Guia de Discussão, onde as escolhas dos elementos da Matriz Resposta para compor a solução de um desafio são confrontadas com comentários apropriados do autor, vi) Pontos de Vista do Autor.

Apesar de ser uma técnica desenvolvida na década de 1960 (Hodgson & Dill, 1970) e ser bastante promissora, em especial para emprego em EaD, a CE tem sido pouca usada. Um dos motivos é a dificuldade de se especificar boas atividades instrucionais. Além disso, o processo de autoria em atividades instrucionais ou exercícios de CE pode gerar algumas inconsistências ou incoerências entre o conteúdo apresentado em suas seções (Galante, 2008). Como exemplo desse tipo de inconsistência, pode-se citar o trabalho de Fyfe & Woodrow (1969). No exercício número 1 desse trabalho, a Matriz Resposta apresenta o conceito “The Morgan’s law” na primeira posição da matriz. Contudo, esse conceito não é apresentado nem discutido na seção Apresentação do exercício. Seria esse conceito um pré-requisito necessário ao aluno para a solução de algum desafio? Se sim, essa informação deveria estar contida na seção Intenção da CE, o que não ocorreu.

Galante (2008) apresenta uma lista de tipos de incoerências em exercícios de CE especificadas por meio de notação formal baseada em grafos e Teoria de Conjuntos. Embora os grafos espelhassem os mapas conceituais correspondentes, a notação em grafos e subgrafos criava uma certa barreira para o autor de atividades instrucionais entender o que estava sendo verificado. Neste trabalho, apresentamos a lista de 19 tipos de incoerências em exercícios de CE, complementando o trabalho de Galante e de acordo com requisitos levantados por Noronha (2005), apenas por meio de mapas conceituais e Teoria de Conjuntos, de modo a facilitar o trabalho do autor de atividades instrucionais.

Traduzindo os mapas conceituais manualmente para o formato de proposições, que é usado pela ferramenta de grafos e conjuntos de Galante (2008), pudemos fazer uso do workbench de testes desenvolvido por ele e assim validar as especificações de incoerências propostas. Exemplos teóricos e da literatura foram examinados, demonstrando que o modelo é adequado para encontrar incoerências na autoria de atividades instrucionais do tipo CE.

2 Estrutura da Comunicação Estrutural e sua Representação por Meio de Mapas Conceituais

Mapa conceitual, segundo Novak & Cañas (2006), é uma ferramenta que pode ser utilizada para organizar e representar conhecimento. Devido ao seu poder representacional e simplicidade de compreensão, é recomendada por Egan (1976) como mecanismo de auxílio ao autor de atividade instrucional do tipo CE. Os conceitos são visualizados dentro de caixas, ou nós do grafo, enquanto que as relações entre os conceitos são especificadas através de frases de ligação nos arcos que unem os conceitos. A proposição é uma característica particular dos mapas conceituais e é formada quando dois ou mais conceitos são conectados por frases de ligação que formam uma unidade semântica (Novak & Cañas, 2004).

A seguir, cada uma das cinco primeiras seções de uma atividade instrucional formatada segundo a CE é descrita e exemplificada. O assunto ilustrado na forma de CE, retirado de Galante (2008), é a Introdução da Unidade III, “Feudalismo e o Período Medieval”, do livro do ensino fundamental de Vicentino (1997), dentro do tema História Geral. A última seção, Pontos de Vista do Autor, por ter uma estrutura livre a critério do autor da atividade de aprendizagem do tipo CE, não será tratada nem exemplificada com mais detalhes neste trabalho.

2.1 Intenção

A seção Intenção define o que deverá ser aprendido e em que intensidade. Fornece uma visão geral dos objetivos e o contexto para o conteúdo da unidade de estudo. A Figura 1 ilustra uma seção Intenção para o assunto alvo, enquanto a Figura 2 ilustra um mapa conceitual que a representa. Essa seção foi desenvolvida por Galante [2008] e não faz parte de Vicentino (1997). MC_I denota o mapa conceitual da Intenção, com todas as suas proposições, que incluem todos os conceitos e rótulos que conectam conceitos e formam proposições ali representados.

2.2 Apresentação

A seção Apresentação fornece informações descritivas do assunto instrucional, exercícios e estudos de casos. Pode ser composto de materiais de texto impresso ou digital, vídeos e filmes, simulações, cursos hipermédia, sistemas hipermédia adaptativos, sistemas de tutoria inteligente, jogos eletrônicos, visitas a sites e palestras, entre outras formas. O conteúdo da Apresentação corresponde à Introdução da Unidade III, “Feudalismo e o Período Medieval”, do livro do ensino fundamental de Vicentino (1997).

Intenção
No estudo do período medieval, analisaremos inicialmente a sua estrutura, ou seja, o **feudalismo**: os componentes econômicos e sociais, bem como suas articulações com as concepções políticas e culturais da Idade Média. Em seguida, estudaremos o seu desenvolvimento histórico, ou seja, os acontecimentos que conduziram à formação do feudalismo, durante a Alta Idade Média, e à sua decadência, na Baixa Idade Média.

Figure 1. Exemplo de seção Intenção.

MC_A denota o mapa conceitual da Apresentação do exemplo, com todas as suas proposições, que incluem todos os conceitos e rótulos que conectam conceitos e formam proposições ali representados. Por exemplo, uma proposição é “P: C: Idade Media R: período entre C: Séculos V e XV”; outra é “P: C: Idade Media R: fim C: Tomada de Constantinopla”.

2.3 Investigação de Desafios

A seção Investigação de Desafios ou apenas Desafios apresenta de forma sequencial um conjunto de desafios inter-relacionados. Esses desafios visam atingir ao Objetivo Instrucional proposto e são geralmente questões sobre o assunto da Apresentação. O aprendiz responde ao desafio selecionando os elementos da Matriz Resposta, apresentada na subseção a seguir.

A Figura 2 ilustra uma seção Desafios para o assunto alvo. A Matriz Resposta citada em cada desafio corresponde a possíveis elementos ou conceitos para compor uma solução do desafio, de forma semelhante a questões de múltipla escolha em que mais de um tópico pode ser escolhido. Ela será detalhada na Subseção 2.4.

O autor deve elaborar os desafios, geralmente entre 3 e 5, para que o aprendiz selecione os itens da Matriz Resposta de forma a atingir o objetivo instrucional proposto na Intenção. Seja E um exercício de Comunicação Estrutural; seja DE o conjunto de desafios de E, onde $DE = \{Dk / Dk \text{ é um desafio; } k=1, \dots, T\}$; T é o número

máximo de desafios de DE; usualmente T máximo é 5 e T mínimo é 3; seja MR o conjunto de elementos da Matriz Resposta. Os desafios devem ser definidos de acordo com o seguinte (Egan, 1976; Romiszowski, 2007):

- I. Os conceitos ou proposições a serem abordados pelos desafios devem estar presentes na Apresentação ou Intenção.
- II. Deve haver, no mínimo, um elemento da Matriz Resposta comum nas soluções de cada par de desafios; ou seja, o seguinte deve ocorrer:

$$\{\text{Sol}(D_i) \cap \text{Sol}(D_j) \neq \emptyset \mid \forall (i,j), i \neq j, i, j = 1, \dots, T\}$$

onde $\text{Sol}(D_n)$ representa o conjunto de elementos de MR utilizados na resposta ou solução típica dada pelo autor ao desafio D_n .

- III. O conjunto de elementos utilizados nas soluções típicas dos desafios, juntos, deve abranger, sempre que possível e pertinente, o número máximo de elementos apresentados na seção Matriz Resposta; ou seja, o seguinte deve ocorrer:

$$\{\text{Sol}(D_1) \cup \text{Sol}(D_2) \cup \dots \cup \text{Sol}(D_k) \mid k = 1, \dots, T\} \subseteq \text{MR}$$

Cada desafio D_k pode ser representado por um mapa conceitual, MC_{-Dk} , o qual pode se constituir apenas de um conceito (uma proposição simples incompleta), uma proposição simples completa ou de um mapa conceitual mais elaborado. Por exemplo, o Desafio I da Figura 2 tem o seguinte mapa conceitual: $MC_{-DI} = \{P: C: \text{feudalismo } R: C\}$; ou seja, é uma proposição simples incompleta, composta apenas por um conceito. No Desafio II, o mapa conceitual correspondente já é uma proposição simples completa: $MC_{-DII} = \{P: C: \text{redefinição cultural } R: \text{ocorrência } C: \text{período feudal}\}$. O mapa conceitual correspondente ao Desafio III é apenas um conceito: $MC_{-DIII} = \{P: C: \text{modelo de produção feudal } R: C\}$.

Desafios
DESAFIO I: Quais elementos da Matriz Resposta estão relacionados com o surgimento do feudalismo?
DESAFIO II: Quais elementos da Matriz Resposta melhor descrevem a redefinição cultural ocorrida no período feudal?
DESAFIO III: Quais elementos da Matriz Resposta identificam os aspectos principais do modelo de produção feudal?

Figura 2: Exemplo de seção Desafios.

2.4 Matriz Resposta

A seção Matriz Resposta é formada por uma matriz de elementos aleatoriamente distribuídos distintos, geralmente entre 20 e 40, do domínio sob estudo. Os elementos podem ser frases que resumem uma idéia, palavras-chave, conceitos isolados, princípios contidos na Apresentação ou Intenção etc. Os elementos da Matriz Resposta formam um vocabulário comum entre o aprendiz e o tutor. Com esse vocabulário, o aprendiz compõe soluções para o desafio. O aprendiz constrói uma solução selecionando os elementos da Matriz Resposta que considera como parte da resposta ao desafio correspondente.

A Figura 3 ilustra uma Matriz Resposta para o assunto alvo. Assim, neste caso o conjunto de elementos da Matriz Resposta $MR = \{m_1, 1, m_1, 2, \dots, m_3, 4\}$; ou seja, têm-se 12 elementos. Cada um desses elementos podem ter o seu mapa conceitual. Por exemplo, o elemento $m_1, 1$ tem o seguinte mapa conceitual, representado por meio de proposições: $MC_{-m1,1} = \{P_{11}: C: \text{Economia autossuficiente } R: C\}$, onde P_{11} indica que é um proposição do elemento $m_1, 1$. O elemento $m_1, 4$ tem o seguinte mapa conceitual: $MC_{-m1,4} = \{P_{14}: C: R: \text{surgimento } C: \text{Teologia-Filosofia}\}$, que é ainda uma proposição incompleta, pois falta definir o primeiro conceito da proposição.

MC_{-MR} denota o mapa conceitual da Matriz Resposta e consiste no seguinte:

$$MC_{-MR} = \{MC_{-m1,1} \cup MC_{-m1,2} \cup \dots \cup MC_{-m_i, j} \mid i \text{ número de linhas e } j \text{ de colunas}\}$$

Usando técnicas de combinação de mapas conceituais (Fernandes, 2008), pode-se combinar todos os submapas em apenas um grande mapa conceitual MC_{-MR} . Se após a combinação dos submapas ainda restar alguma proposição incompleta, o grande mapa será incompleto também. Todavia, isso não é problema neste contexto, pois, como o interesse é nos conceitos presentes no mapa, será irrelevante para a determinação de incoerências na atividade de Comunicação Estrutural se MC_{-MR} for incompleto ou não.

m_{1,1} Economia auto-suficiente.	m_{1,2} Invasões Bárbaras motivaram a queda do Império Romano em 476.	m_{1,3} A filosofia contraiu nova aliança, desta vez com a teologia.	m_{1,4} Surgimento da Teologia-Filosofia.
m_{2,1} A população deixou as cidades, buscando sobrevivência nos campos, praticada nas vilas (grandes propriedades agrárias), constituiu a base de uma economia auto-suficiente, cujos desdobramentos conduziram à formação do mundo agrário-feudal.	m_{2,2} Maneira de produzir subsistência que teve relações sociais e uma ordem política e cultural específicas.	m_{2,3} A ciência perdeu a vitalidade e a velha união com a filosofia se dissolveu.	m_{2,4} Os homens, com o trabalho, transformam a natureza, da qual extrafiam bens necessários à sobrevivência.
m_{3,1} Período entre os séculos V e X, chamado de Alta Idade Média.	m_{3,2} Edificou-se na Europa Ocidental em substituição a estrutura escravista do período anterior.	m_{3,3} A vida intelectual se processou sob orientação da igreja.	m_{3,4} Início da Idade Média ou Período Medieval.

Figura 3: Exemplo de seção Matriz Resposta.

2.5 Guia de Discussão

A seção Guia de Discussão é composta por duas partes: um conjunto de regras de inclusão ou omissão de determinado elemento da Matriz Resposta; um conjunto de comentários elaborados pelo autor, onde cada comentário está associado a apenas uma das regras e vice-versa. Os comentários devem ser lidos pelo aprendiz, possuem propósitos construtivos e discutem em profundidade o raciocínio utilizado pelo aprendiz quando inclui ou não elementos da Matriz Resposta em sua resposta. Raramente se classifica uma resposta como incorreta e nunca se fornece uma resposta correta; de preferência, encoraja-se o aprendiz a pensar novamente ou mais profundamente nos assuntos abordados.

A sequência de escolhas de regras e leitura de comentários correspondentes e ações daí decorrentes configura uma estrutura de diálogo simulado entre aprendiz e autor da atividade instrucional, se segue a linha de raciocínio que fez o aprendiz selecionar aqueles elementos especificamente para um dado desafio. Outro aprendiz poderá seguir outra linha de raciocínio e em consequência levar a outra ordem de diálogo com a atividade instrucional. Determinar essas possíveis direções do raciocínio do aprendiz é uma tarefa não trivial. A sua obtenção pode ser auxiliada por especialistas do domínio, experiência do autor, experimentos realizados, catálogos de erros, pedagogos e psicólogos, dentre outras formas.

A Figura 4 ilustra uma seção Guia de Discussão – Parte das Regras de Inclusão e Exclusão para o Desafio I do assunto alvo.

DESAFIO I:
1. I all of m _{1,2} , m _{1,4} , m _{2,1} , m _{3,1} , m _{3,2} and m _{3,4} → A
2. O anyone of m _{1,2} , m _{1,4} , m _{2,1} , m _{3,1} , m _{3,2} and m _{3,4} → B
3. I anyone of m _{1,3} , m _{2,3} and m _{3,3} → C
4. I anyone of m _{1,1} , m _{2,2} and m _{2,4} → D

Figura 4: Exemplo de uma seção Guia de Discussão – Parte das Regras de Inclusão e Exclusão para o Desafio I.

A CE permite especificar que os relacionamentos entre conceitos, representados pelos elementos da Matriz Resposta, possam ser classificados quanto a gênero de agrupamento como sendo do tipo “e” ou “ou”. A funcionalidade do conceito pode assumir o valor “inclusão” ou “omissão”, indicada respectivamente por “I:” (inclua) ou “O:” (omita) antes da regra. Nesse trabalho de pesquisa não se considerou o cruzamento dos tipos “I:” e “O:” simultaneamente em uma regra do Guia de Discussão, onde uma dada regra pudesse simultaneamente, por exemplo, incluir um dado elemento e excluir outro elemento. O Desafio I da Figura 4 ilustra a notação da regra para ser entendida pelo autor da atividade de aprendizagem; na Tabela 1, as regras encontram-se codificadas de forma equivalente mas formal para serem entendidas pelo computador.

Quando um autor de um exercício define um relacionamento entre dois elementos da Matriz Resposta numa dada regra, por exemplo, m_{1,2} e m_{2,3}, ele necessita informar qual o tipo de relacionamento (“e” ou “ou”) e qual

a funcionalidade do conceito “inclusão” ou “omissão”. A Tabela 1 ilustra que, para a elaboração das regras, o uso dos operadores lógicos “e” e “ou” em uma regra são entendíveis ou representados por \parallel (OU) e $\&\&$ (E). Por exemplo, na Figura 4, Desafio I, a regra 1 é do tipo “e” (indicado por “all of”;) e “I:”; já a regra 2 é do tipo “ou” (indicado por “anyone of”) e “O:”. Assim, a regra 1 mais formalmente deve ser entendida da seguinte forma: “I: m_{1,2} $\&\&$ m_{1,4} $\&\&$ m_{2,1} $\&\&$ m_{3,1} $\&\&$ m_{3,2} $\&\&$ m_{3,4}”. A Tabela 1 apresenta as codificações para as outras três regras.

O Guia de Discussão, proposto e representado na forma da Tabela 1, auxilia o autor na elaboração das regras em relação a cada alvo de discussão. A discussão é orientada a sanar ou reduzir os problemas de compreensão dos aprendizes dos conceitos errôneos ou inadequados e dos conceitos faltantes relacionados com a solução de um dado desafio, buscando fortalecer a aprendizagem dos conceitos adequados ou corretos. Por exemplo, se ao tentar solucionar o Desafio I, o aprendiz opta por escolher a regra 2, ele é orientado a ler o comentário B. Nesse comentário, ele será alertado para a falta de conhecimento de um dado conceito e pedirá que ele retorne à seção Apresentação, por exemplo, para verificar o relacionamento desse conceito faltante com a solução do desafio. E assim ele deverá prosseguir, até se convencer que a regra 1 é a mais adequada para resolver o desafio.

Tabela 1: Exemplo da seção Guia de Discussão – Parte das Regras para o Desafio I codificadas e associadas aos Comentários.

#regra	DESAFIO	ALVO	REGRA	COMENTÁRIO
1	I	conceito adequado	I: m _{1,2} $\&\&$ m _{1,4} $\&\&$ m _{2,1} $\&\&$ m _{3,1} $\&\&$ m _{3,2} $\&\&$ m _{3,4}	A
2	I	conceito faltante	O: m _{1,2} \parallel m _{1,4} \parallel m _{2,1} \parallel m _{3,1} \parallel m _{3,2} \parallel m _{3,4}	B
3	I	conceito inadequado	I: m _{1,3} \parallel m _{2,3} \parallel m _{3,3}	C
4	I	conceito inadequado	I: m _{1,1} \parallel m _{2,2} \parallel m _{2,4}	D

O princípio fundamental do conjunto de regras é a completeza, de modo que haja sempre alternativas que possam cobrir as possibilidades de resposta do aprendiz. Por exemplo, no Desafio I, todos os elementos da Matriz Resposta foram usados na regra, de modo que aparentemente todas as possibilidades de incluir algum elemento da Matriz Resposta recairá em alguma das quatro regras oferecidas. No entanto, trata-se de uma tarefa difícil produzir Guias de Discussão dentro desse princípio. Por exemplo, o raciocínio errôneo do aprendiz pode levar a uma regra do tipo “O any two or more of m1,3, m2,3 and m3,3 → Comentário E”, que não se encontra disponível para escolha do aprendiz no Desafio I. Por isso, alguns autores colocam uma regra “default”, que acolheria qualquer raciocínio errôneo não previamente vislumbrado pelo autor; no caso da regra acima, o autor deveria escrever adequadamente o comentário E, de modo a atenuar os problemas de compreensão do aprendiz e ajudá-lo a entender os problemas com sua forma de pensar ao resolver o problema. Portanto, automatizar de alguma forma o processo de verificar essa completeza será de grande valia aos autores de atividades de CE.

MC_Com(Cr) denota o mapa conceitual de um Comentário com rótulo Cr, $r = 1, \dots, C$, $C =$ número total de comentários. Por exemplo, o Comentário A, indicado quando o aprendiz escolhe a regra 1 da Tabela 1, deverá ter o mapa conceitual associado MC_Com(A) especificado. Um comentário deve tratar de conceitos que aparecem tanto na Intenção quanto na Apresentação.

3 Detecção de Incoerências em Exercícios de CE por Meio de Mapas Conceituais

Basicamente existem 3 tipos de incoerências em CE que precisam ser detectadas: i) Detecção de Duplicidade ou Contradição: elementos são redundantes ou se contradizem num dado mapa conceitual? Seja MC um dado mapa conceitual e m e p submapas conceituais eventualmente formados de apenas um conceito, $\{m \subset \square\square\square\square\square\} | p \subset \square\square MC\}$ m = p (conceitos redundantes) ou m = !p (conceitos que se negam ou se contradizem); ii) Detecção de Presença: elemento de MC1 não está em MC2 quando deveria estar? Sejam MC1 e MC2 mapas conceituais; $\{m \subset \square\square C1\} | m \not\subset \square\square MC2\}$ iii) Completeza de regras no Guia de Discussão, que não é o alvo desta pesquisa.

A seguir, iremos visitar cada seção CE e identificar e especificar os três tipos de incoerências pertinentes. A numeração não segue a apresentada no trabalho de Galante (2008). Note-se que nem sempre uma incoerência detectada é verdadeiramente uma incoerência; pode ser que o autor queira que seja do jeito que está sendo interpretado aqui como incoerência. A palavra final se a incoerência deve ser removida ou não fica a critério do autor.

Incoerências na Seção Intenção

Inc-1) Conjunto de conceitos ou proposições na Intenção que são iguais; ou seja, representam um mesmo conceito ou proposição.

$$\{m \subset MC_I, p \subset MC_I \mid m = p\}$$

Inc-2) Conjunto de conceitos ou proposições na Intenção que se negam ou se contradizem.
 $\{m \subset MC_I, p \subset MC_I \mid m = !p\}$, onde “!” representa a negação da proposição.

Inc-3) Não se pode ter conceitos ou proposições na Intenção que não estejam presentes na Apresentação, a menos que sejam pré-requisitos.

$$\{m \subset \square C_I \mid m \not\subset MC_A\} \text{ ou } \{MC_I \not\subset MC_A\}$$

Incoerências na Seção Apresentação

Inc-4) Conjunto de conceitos ou proposições na Apresentação que são iguais; ou seja, representam um mesmo conceito ou proposição.

$$\{m \subset MC_A, p \subset MC_A \mid m = p\}$$

Inc-5) Conjunto de conceitos ou proposições na Apresentação que se negam ou se contradizem.
 $\{m \subset MC_A, p \subset MC_A \mid m = !p\}$

Incoerências na Seção Investigação de Desafios

Inc-6) Os conceitos ou proposições a serem abordados pelos desafios não estão presentes na Apresentação ou Intenção.

$$\{m \subset \square C_D \mid m \not\subset \square MC_I \cup \square MC_A, k = 1, \dots, T, T = \text{número máximo de desafios}\}$$

Inc-7) Não há um elemento da Matriz Resposta comum nas soluções de algum par de desafios; ou seja, o seguinte deve ocorrer:

$$\{\text{Sol}(D_i) \cap \text{Sol}(D_j) = \emptyset \mid \exists (i,j), i \neq j, i, j = 1, \dots, T, T = \text{número máximo de desafios}\}$$

onde Sol(Dn) representa os elementos de MR utilizados na resposta ou solução típica dada pelo autor ao desafio Dn e seja MR o conjunto de elementos da Matriz Resposta.

Inc-8) O conjunto de elementos utilizados nas soluções típicas dos desafios não abrange o número máximo de elementos apresentados na seção Matriz Resposta.

$$\text{Sol(DE)} = \{\text{Sol}(D_1) \cup \text{Sol}(D_2) \cup \dots \cup \text{Sol}(D_k) \mid k = 1, \dots, T, T = \text{número máximo de desafios}\}$$

Então, $|\text{Sol(DE)}| < |\text{MR}|$, ou seja, número de elementos de Sol(DE) é menor que número de elementos de MR.

Incoerências na Matriz Resposta

Inc-9) Conjunto de elementos da Matriz Resposta que é um pré-requisito ao aprendiz para a solução de um dado Desafio não está contido na Apresentação ou Intenção.

$$\{m \subset \square C_{MR} \mid m \not\subset \square MC_I \cup \square MC_A\}$$

Inc-10) Conjunto de elementos na Matriz Resposta que são iguais; ou seja, representam um mesmo elemento.

$$\{MC_{mi,j} \subset \square MC_{MR}, MC_{mk,l} \subset \square MC_{MR} \mid MC_{mi,j} = MC_{mk,l}, i, j, k, l = 1 \dots T, T = \text{número máximo de desafios}\}$$

Incoerências nos Comentários do Guia de Discussão

Inc-11) Os conceitos ou proposições dos Comentários do Guia de Discussão não estão presentes na Apresentação ou Intenção.

$$\{m \subset \square MC_{Com(Cr)} \mid m \not\subset \square MC_I \cup \square MC_A, r = 1, \dots, C, C = \text{número total de comentários}\}$$

Inc-12) Conjunto de conceitos ou proposições nos Comentários que são iguais; ou seja, representam um mesmo conceito ou proposição.

$$\{m \subset MC_A, p \subset MC_A \mid m = p\}$$

Inc-13) Conjunto de conceitos ou proposições nos Comentários que se negam ou se contradizem.

$$\{m \subset MC_A, p \subset MC_A \mid m = !p\}$$

Incoerências nas Regras do Guia de Discussão

Seja Cri = rótulo de comentário associado à regras ri, i = 1, ..., RD, RD = Conjunto de Regras.

Inc-14) Regras iguais no Guia de Discussão, em que, no pior caso, levem a comentários diferentes, o que jamais deve ocorrer numa atividade de CE.

$$\{ri \in RD, rk \in RD \mid ri = rk\}$$

Duas regras diferentes guiam o aprendiz a um mesmo comentário, ou cada uma das guia o aprendiz para dois comentários diferentes cujo conteúdo é o mesmo, incoerências do tipo convergente.

Inc-15) $\{ri \in \square RD, rk \in \square RD \mid ri \neq rk \text{ e } Cri = Crk, i, k = 1, \dots, RD, RD = \text{Conjunto de Regras}\}$

Inc-16) $\{ri \in RD, rk \in RD \mid ri \neq rk \text{ e } Cri = Crk \text{ e } MC_Com(Cri) = MC_Com(Crk), i, k = 1, \dots, RD, RD = \text{Conjunto de Regras}\}$

Por outro lado, uma incoerência do tipo divergente no Guia de Discussão é verificada quando, para um mesmo desafio, existem duas regras iguais que guiam o aprendiz a comentários diferentes.

Inc-17) $\{ri \in \square RD, rk \in \square RD \mid ri = rk \text{ e } Cri \neq Crk, i, k = 1, \dots, RD, RD = \text{Conjunto de Regras}\}$

Outra incoerência relacionada ao Guia de Discussão consiste em o autor deixar de incluir algum elemento da Matriz Resposta em alguma das regras do conjunto de regras. Considerando que MR é o conjunto de elementos da Matriz Resposta e CER é o conjunto de elementos contidos nas regras relacionados com um determinado desafio, tem-se o seguinte, neste caso:

Inc-18) $|MR \cap CER| \neq |MR|$, número de elementos

Ainda em relação ao Guia de Discussão, uma incoerência é constatada quando o autor elabora uma regra que assume ou contém outra regra.

Inc-19) $\{ri \in \square RD, rk \in \square RD \mid ri \subset rk, i, k = 1, \dots, RD, RD = \text{Conjunto de Regras}\}$

4 Considerações Finais

Este artigo apresentou os pressupostos teóricos referentes a um modelo computacional para identificação de incoerências no processo de autoria em Comunicação Estrutural (CE). O modelo empregado ajuda a evidenciar e enumerar formalmente as incoerências, utilizando-se de uma representação fundamentada em mapas conceituais e Teoria dos Conjuntos. Galante (2008) desenvolveu a ferramenta SCII (Structural Communication Incoherence Identifier) que manipula grafos e operações de conjuntos; ela armazena e lê grafos no formato de proposições. Ao combinar nosso trabalho com o de Galante, obtemos a capacidade de termos nossos mapas conceituais computacionalmente interpretáveis quanto às incoerências das atividades no formato CE.

Galante também desenvolveu um workbench de testes composto de quatro atividades de aprendizagem no formato da Comunicação Estrutural: “O Feudalismo e o Período Medieval” (Adaptado para CE por Galante, material original de Vicentino, 1997), um conjunto de atividades adaptadas sobre “Ensino de Química” (Johnstone, 1988; Johnstone, 2003; Johnstone & Ambusaidi, 2001), uma atividade adaptada do material “Comunicação Estrutural” (Romiszowski, 2003). Cada um dessas atividades CE foram preparadas para incorporar os diversos tipos de incoerências que tratamos neste trabalho.

Os mapas conceituais podem ser representados na forma de grafos. Com grafos é possível representar conceitos e seus relacionamentos em um formato logicamente preciso, humanamente legível e computacionalmente interpretável. Existem diferentes ferramentas na literatura que transformam mapas conceituais em algum tipo de grafo (Amorim et al., 2003; Sowa, 2004). Contudo, tivemos dificuldades de usar essas ferramentas da literatura. Galante havia usado o CMaptools (2007) para definir os mapas conceituais de cada seção CE para as quatro atividades acima. Por causa do formato de armazenamento usado, foi preciso traduzir os mapas conceituais dessas atividades manualmente para o formato de proposições, que é usado pela ferramenta de grafos e conjuntos.

Após passar cada uma das quatro atividades na SCII em busca de incoerências, constatamos que o resultado foi promissor, pois conseguimos validar as especificações de incoerências propostas, uma vez que todas as incoerências incorporadas nas atividades de propósito foram encontradas e registradas pela ferramenta. Isso

mostra que o modelo parece ser adequado para encontrar incoerências na autoria de atividades instrucionais do tipo CE.

Como trabalho futuro, pretende-se integrar a ferramenta de Galante (2008) num editor de atividades do tipo CE e permitir , além de armazenar os mapas conceituais no formato do SCII, detectar em background os diversos tipos de incoerências levantadas e especificadas, apontando em tempo de autoria quando alguma incoerência for detectada. Adicionalmente, pretende-se também auxiliar a obter mapas conceituais diretamente de textos digitais, para acelerar a edição de atividades CE (Kowata, 2010; Valerio et al. 2012).

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DIFICULTADES DE APRENDIZAJE Y UTILIZACIÓN DE MAPAS CONCEPTUALES EN EL AULA: UMA PERSPECTIVA HUMANISTA DE LA INCLUSIÓN A PARTIR DE NOVAK Y MATORANA

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Resumen: Este artículo presenta una elaboración teórica que discute el concepto de inclusión escolar en particular en las situaciones de niños y jóvenes con dificultades de aprendizaje vinculadas a trastornos de procesamiento sensorial. Como alternativa se discute la perspectiva humanista de la educación a partir del concepto de *empowerment* de Joseph Novak y de la epistemología de Humberto Maturana. Esta reflexión nos lleva a proponer la utilización de los mapas conceptuales como un instrumento metodológico también para la formación de profesores que puedan trabajar con niños con discapacidad o dificultades de aprendizaje. El objetivo es que con el uso de mapas de conceptos en sala de aula los profesores realmente promuevan la plena participación y el aprendizaje de todos sus estudiantes.

Palabras-clave: inclusión escolar, *empowerment*, epistemología biológica, trastorno de procesamiento sensorial, mapas conceptuales.

1 Introducción

La UNESCO ha definido la educación inclusiva desde la declaración de Salamanca en 2004 (Torres, 2013) como una respuesta a las diversas necesidades de los estudiantes, aumentando su participación en los diferentes aprendizajes, en las culturas y en las comunidades, reduciendo así la exclusión dentro y desde la educación. Para la UNESCO (2009b) es de responsabilidad del sistema regular de cada país educar a todos los niños y, por lo tanto, esto significa modificaciones en el contenido, en los enfoques y en las estrategias utilizadas para la enseñanza. Desde la declaración de Salamanca el concepto de educación inclusiva se ha diseminado en nuestros países latinoamericanos, desgraciadamente con una falta de formación para los profesores sobre el sentido profundo de la necesidad de ofrecer oportunidades de aprendizaje y de convivencia para todos los niños y jóvenes que frecuentan la escuela.

Esta situación ha llevado a una gran paradoja en muchas de nuestras escuelas donde la propuesta de inclusión ha generado nuevas y complejas formas excluyentes, una de ellas se debe a la falta de formación de los profesionales de la educación que al no saber como lidiar con las dificultades de diversas naturalezas presentadas por sus estudiantes acaban generando otras formas de exclusión. Para Yadarola (2006) hoy día tenemos una escuela inclusiva parcial, pues en primer lugar la formación de los profesores en este campo es incompleta e insatisfactoria, en segundo lugar, algunos profesionales están acostumbrados a realizar diagnósticos de sus alumnos utilizando enfoques clasificatorios y en tercer lugar la autora discute la falta de necesidad de la “doble escolarización” a la que muchos de estos niños y jóvenes se ven sometidos. Para explicar mejor esta situación, ejemplificaré con el caso hipotético de un niño de inclusión de una escuela, el profesor que no está preparado, solicita un auxiliar, un acompañante terapéutico o pedagógico, ciertamente para ayudar en su aprendizaje, lo que puede ocurrir es que el niño no realice las actividades junto con sus colegas; que las actividades sean repetitivas o muy simples, y no ofrezcan realmente desafíos cognitivos para las habilidades y posibilidades cognitivas del niño. Las consecuencias son entonces generadas: desmotivación, desinterés, fracaso, y el círculo vicioso de la necesidad de apoyo psicopedagógico extra-escuela, lo que Yadarola (2006) llama de “doble escolarización” se consolida entonces, y el niño o joven que precisaba ser integrado al sistema escolar acaba siendo desintegrado por no responder a ese mismo sistema.

Para el filósofo español Fernando Savater, los seres humanos nascemos dos veces, una vez del útero materno, biológicamente natural, y una segunda vez del útero social, en un grupo que nos acepta, acoge y nos da identidad. Este segundo nacimiento es más importante que el primer nacimiento pues es este el que desarrolla en nosotros las posibilidades de humanidad (Savater, 2006). El segundo nacimiento muchas veces ocurre en un grupo social diferente de nuestra familia que nos acoge incondicionalmente, este, puede ocurrir en la escuela. Si la escuela exige apenas un tipo de habilidad o no considera la diversidad de los niños, es muy probable que el segundo parto, el parto social, en las palabras de Savater sea un fracaso.

En esa perspectiva, Novak & Cañas (2010) indican que es bueno que en la actualidad las escuelas estén reconociendo la existencia de diferentes habilidades humanas importantes, habilidades estas que van más allá de

la memorización de informaciones cognitivas específicas. Una de las razones que Novak & Cañas (2010) indican como fundamental para incentivar la integración del amplio espectro de actividades presentes en el nuevo modelo educacional propuesto por ellos a través del uso de los mapas conceptuales, es ofrecer oportunidades para que otras habilidades, poco o nada utilizadas, puedan ser desarrolladas, representadas y expresadas por los niños. Para Savater esto ayudaría a expresar aquello que en sus palabras, se ha dejado de lado. Para Fernando Savater, se habla excesivamente y sin entender claramente de la diversidad de los seres humanos en la educación, algo obvio, sin embargo, deberíamos hablar que la riqueza humana es nuestra semejanza. Nuestra capacidad de comprendernos de, hacer las cosas de diferentes formas. En suma, estamos capacitados para comprendernos y para comunicarnos y todo nuestro esfuerzo, debería ir en esa dirección (Savater, 2006).

2 Dificultades de Aprendizaje relacionadas con la Integración Sensorial

Abordaré en este texto algunas dificultades de aprendizaje y/o de socialización presentadas por algunos niños y jóvenes en edad escolar, cuya origen no es identificada con claridad por profesores o especialistas y terapeutas, se trata de Trastornos de la Integración Sensorial, para ello adaptaré algunas informaciones divulgadas por mí en un texto producido en portugués (Infante-Malachias, 2013).

La responsabilidad por la percepción del mundo y por los estados del medio orgánico interno es de nuestros sistemas sensoriales. Estos sistemas sensoriales alimentan el sistema nervioso central (SNC) con una gran cantidad de informaciones, también le informan sobre muchos aspectos del medio orgánico interno, para diversos ajustes del funcionamiento del organismo, sin la necesidad de llegar al nivel consciente (Silveira, 2008). La comunicación entre el medio externo o el medio orgánico interno del individuo y el SNC que es el responsable por procesar la información y emitir las respuestas adecuadas a los estímulos percibidos ocurre a través de los receptores sensoriales, los que pueden ser llamados de elementos críticos de todos los sistemas sensoriales. Ellos permiten la “percepción” de los estímulos, su naturaleza e intensidad.

De una manera simplificada, todos nosotros estamos muy familiarizados con lo que conocemos como los cinco sentidos básicos (visión, audición, gusto, tacto y olfato) denominados en las neurociencias como sentidos especiales, porque ellos captan informaciones sensoriales o sensibilidades especiales (Lent, 2008). Esos cinco sentidos son reconocidos como sentidos externos, porque ofrecen respuestas para sensaciones que provienen del exterior de nuestro cuerpo, y en la medida en que un niño se desarrolla desde el útero de su madre, los sistemas sensoriales van madurando y el cerebro va perfeccionando el registro sensorial de los sentidos básicos.

Las modalidades sensoriales son más que los cinco sentidos básicos citados anteriormente, Momo *et al.* (2011b) indican además de la visión, audición, el gusto, el olfato y la somestesia (que incluye tacto, propiocepción, dolor y temperatura), el sistema vestibular. El sistema vestibular organiza todas las informaciones que provienen del movimiento corporal, de gravitación, de aceleración, de rotación, y de equilibrio y son procesadas principalmente en el oído interno. El sistema proprioceptivo registra todas las informaciones de postura corporal mediante presión, esto es, permite el registro de la tracción y del movimiento muscular, de la misma manera el estiramiento de tendones. En resumen, la propiocepción es la sensación de músculos y tendones, la fuerza necesaria, por ejemplo, para dar un abrazo, para tomar un lápiz y escribir.

Cada sistema sensorial tiene sus especificidades, funcionales, morfológicas y moleculares (Lent, 2008) y la respuesta adecuada de los sistemas sensoriales indica un desarrollo también adecuado del niño con las respuestas adaptadas a las demandas del medio. Una información de gran importancia fue dada por Antonio Damásio (2010) con respecto a todos los canales sensoriales. De acuerdo con Damásio, no existe la percepción pura de un objeto, por ejemplo, la visión. Para la percepción visual de un objeto o para cualquier otro tipo de percepción (auditiva, sonora, olfativa, etc.), el organismo necesita tanto de las señales sensoriales especializadas como de las señales provenientes del ajustamiento del cuerpo que son necesarias para que ocurra la percepción.

La información guardada en la memoria de manera significativa al mismo tiempo como un registro perceptivo y como reacción emocional constituyen elementos de gran importancia para la percepción del mundo y para el aprendizaje de los seres humanos. Estas informaciones deberían ser parte de los currículos de los cursos de formación de profesores, pues muchas veces en la ausencia de hipótesis que expliquen comportamientos diferentes o dificultades de aprendizaje de muchos niños y jóvenes, simplemente estos son discriminados y en muchos casos, medicados inadecuadamente.

2.1 La Integración Sensorial y Aprendizaje

De manera sintética y de acuerdo con Momo *et al.* (2011b), el procesamiento sensorial involucra la captación de las informaciones del ambiente que son conducidas al SNC para ser analizadas y, de acuerdo con las autoras, posteriormente, poder construir una representación interna de los eventos naturales. El cerebro debe organizar un sistema de comunicación de millones de datos para que las respuestas adaptativas integren los repertorios de conocimientos de los seres humanos. Este proceso neurológico fue denominado de Integración Sensorial por la terapeuta ocupacional norte americana Jean Ayres entre 1960 y 1970.

El aprendizaje depende de la habilidad de: recibir las informaciones sensoriales del ambiente y/o del ambiente interno del organismo, procesarlas, integrarlas al SNC y usarlas para planificar y organizar el comportamiento. De manera que se produzca una respuesta adecuada a las necesidades del desarrollo (Momo *et al.* 2011a).

Cuando el procesamiento de las informaciones sensoriales ocurre de forma adecuada y armoniosa, el comportamiento emitido es visto por un observador externo, como adecuado al contexto. Sin embargo, cuando existe inmadurez en el SNC, la habilidad de procesar y organizar las informaciones recibidas es deficiente y como resultado los comportamientos emitidos parecerán inadecuados para un observador externo.

Las disfunciones en los sistemas sensoriales pueden ser expresadas como hiper-registro, hipo- registro o fluctuación de la respuesta sensorial. Cualquiera de estas alteraciones afectará el desarrollo emocional y social del niño, limitando su capacidad de autorregulación y alerta (Momo *et al.* 2011a).

Cuando un niño, presenta una reacción exagerada o excesiva delante de algún estímulo sensorial (hiper-registro sensorial), generalmente muestra respuestas defensivas o protectoras frente a estímulos que, para él, son amenazadores. Esta condición sensorial puede presentarse como recusa a tocar ciertos materiales, recusa al contacto físico, sensibilidad a ruidos cotidianos, entre otros. Las respuestas de comportamiento que son inconscientes y protectoras para el niño, pueden ser, para un observador externo, agresivas, evasivas o de inmovilización. Por otra parte si un niño presenta reacción de insuficiencia a los estímulos recibidos (hipo-registro sensorial) va a expresar su condición biológica en conductas de busca por experiencias sensoriales más intensas una vez que posee una sensibilidad más baja. Este niño tendrá un comportamiento más activo, disperso o desorganizado, es posible que sea un niño que se golpee y no lllore, por ejemplo.

En ambos casos, los comportamientos indican que el SNC no consigue procesar y organizar adecuadamente las informaciones sensoriales provenientes del ambiente (Momo *et al.* 2011a). La consecuencia es que los comportamientos de los niños con disfunción sensorial o con Trastorno del Procesamiento Sensorial (TPS) no son adecuadas a la norma escolar y pueden resultar en comportamientos muy diferentes de lo “normal” esperado lo que generalmente resulta en déficits de aprendizaje o disturbios específicos de percepción, coordinación motora, lenguaje, entre otros. Momo *et al.* (2011a) indican que es común que la mayoría de las veces, por la falta de conocimiento de los adultos que conviven con estos niños, que aparentemente son “normales”, las respuestas dadas por ellos no son comprendidas, siendo mal interpretadas y muchas veces llamadas de mala educación, agresividad, maña, niño mimado, falta de límites etc.

Ciclos constantes de procesamiento sensorial desorganizado resultan en disturbios del desarrollo, de comportamiento y en problemas de aprendizaje.

Tabla 1- Algunos comportamientos que asociados pueden indicar un Trastorno de Procesamiento Sensorial en niños con edad escolar. Adaptado del libro “*O processamento sensorial como ferramenta para educadores: Facilitando o processo de aprendizagem*” de Momo et. al.(2011).

Comportamientos asociados al Trastorno de Procesamiento Sensorial
Agresividad con los compañeros de clase
Se cae de la silla con frecuencia
No consigue permanecer sentado
Cuando está sentado se mueve todo el tiempo
Es desorganizado y distraído.
Su atención es de corta duración
Se frustra fácilmente y no tolera desafíos
Es irritable e impulsivo
Le pega y empuja a sus compañeros cuando se acercan
No tolera ser tocado o no le gusta estar cerca de los otros
Se mueve muy lento o excesivamente rápido
No tolera las clases de Educación Física
Tiene dificultad para determinar la preferencia o lateralidad (izquierda /derecha)
Tiene dificultad con la escritura
Tiene dificultad para mantener la letra en la línea
Permanece siempre en movimiento, tamborilea sus dedos en la mesa, balancea las piernas
Tiene dificultad con actividades de pintura, colaje, argila
Presenta trazado débil, irregular, desalineado
Tiene dificultades para la lectura
Permanece con a escrita espejada o cambia números e letras
Presenta lenguaje inmadura para la edad o problemas al hablar
Es inseguro, retraído, aislado o excesivamente tímido

Cuando estos comportamientos están asociados (Tabla 1) y no existe dificultad de otra naturaleza en el niño puede tratarse de indicadores de Trastorno de Procesamiento Sensorial, muy frecuente en niños o jóvenes con problemas de aprendizaje, que de una manera general no son vistos en sus particularidades ni en sus habilidades, y acaban siendo excluidos por los propios sistemas de inclusión escolar

2.2 La naturaleza humanista de la educación para Joseph Novak

Antes de desarrollar estas ideas quiero enfatizar que una primera aproximación fue realizada en colaboración con mi colega de la Universidad de São Paulo, Brasil, profesor Paulo Correia, en dos trabajos: (Infante-Malachias & Correia, 2009a; 2009b). Todo el texto a seguir contiene actualizaciones de parte de esos textos.

La teoría de educación de Joseph Novak surge como fruto de la convergencia de ideas y de la colaboración entre él y David Ausubel. La gran contribución de Novak es la ampliación de la Teoría del Aprendizaje Significativo restringida a un ámbito apenas cognitivo para un ámbito mucho más amplio que considera al individuo y sus experiencias como un todo, esta perspectiva se aproxima de la visión de conocimiento desarrollada por Maturana y explicada por las neurociencias a través de la integración sensorial. Para Novak, en este primer momento del planteamiento de su teoría (Novak, 1981), la educación es el conjunto de experiencias cognitivas, afectivas y psicomotoras que en conjunto contribuyen para el engrandecimiento del individuo

(*empowerment*), para saber lidiar con las diversas situaciones que debe enfrentar en su vida diaria (Moreira, 1999).

En ese sentido Joseph Novak en su teoría educacional cambia la perspectiva apenas cognitivista dada por Ausubel para una visión que incluye la perspectiva humanista al proponer que cualquier iniciativa educativa además de promover aprendizajes significativos debería promover el engrandecimiento de los individuos, esto significa contribuir con el fortalecimiento de su auto estima y confianza (Mintzes *et al.*, 2004a; Mintzes *et al.*, 2004b). Esto significa que el aprendizaje no puede restringirse solamente a los aspectos cognitivos y que la educación debe ayudar a los individuos no apenas a organizar y estructurar los conocimientos, sino que debería considerar aspectos afectivos, habilidades y estrategias de pensamiento y de acción. La idea de *empowerment* o empoderamiento de Novak, caracteriza el constructivismo humano, que valoriza las relaciones humanas dentro y fuera de la sala de aula, donde los componentes afectivo y emocional son considerados tan importantes cuanto el componente cognitivo.

La densidad y el alcance de esta teoría educacional fue ampliada con la elaboración de los mapas conceptuales por Novak y por toda la profundización teórica y práctica desarrollada junto con Alberto Cañas en una serie de trabajos que a cada día revelan las potencialidades de los mapas conceptuales y los fundamentos teóricos de la teoría educacional (Novak & Cañas, 2010). Para los autores, y pensando en el objetivo de este texto, existe una relación entre la psicología del aprendizaje y la filosofía, en que la creación de nuevos conocimientos es un proceso constructivo que involucra tanto nuestro conocimiento cuanto nuestras emociones, lo que en las palabras de los autores, significa también el impulso de crear nuevos significados y nuevas maneras de representar esos significados. Para ellos: “*Os próprios alunos envolvidos na criação de bons mapas conceituais estão se dedicando a um processo criativo, o que pode ser desafiador, especialmente se esses alunos passaram a maior parte da vida aprendendo mecanicamente. O aprendizado mecânico contribui muito pouco para as nossas estruturas de conhecimento, portanto não pode servir de base para o pensamento criativo ou para a resolução de problemas novos*”. (Novak & Cañas, 2010, p. 15).

La perspectiva Novackiana de *empowerment* surge inicialmente con un carácter individual y se refiere principalmente a las creencias sobre las propias capacidades y competencias, esto significa que tiene un importante componente psicológico, una vez que objetiva favorecer la autoestima y la autoimagen, elementos esenciales para la realización efectiva de tareas y actividades por parte del individuo, concepto denominado de auto-eficacia. Sin embargo, a esta perspectiva educacional Cañas introduce la idea de trabajo en conjunto y trabajo en colaboración (Cañas *et al.*, 1995, Cañas *et al.*, 2001) por lo tanto el concepto de *empowerment* pasa a ser colectivo también.

Desde la perspectiva de la psicología social, el empoderamiento individual precisa además del componente psicológico, de la comprensión del contexto socio-político, o también denominada conciencia crítica. Esto significa que los individuos además de conocer lo que pueden y saben, deben también tener la capacidad de analizar o entender su propia situación social y política, identificando quien tiene el poder, o simplemente quien tiene poder y recursos, entre otros aspectos. En este sentido, una condición de poder que niegue la posibilidad de dialogar, de ejercitar diferentes habilidades, de hacer, de aprender de maneras diferentes, como en un aula donde apenas el profesor tiene voz, elimina toda perspectiva de empoderamiento tanto individual como comunitario. Por este motivo es necesario que en las acciones educativas, particularmente en las llamadas inclusivas, todos participen y tengan oportunidad de expresión, para que el empoderamiento sea también comunitario y social – y esto pueda provocar verdaderas transformaciones sociales – no apenas cambios políticamente correctos en el aula para tranquilidad del profesor, del equipo gestor de la escuela e inclusive del gobierno (Infante-Malachias & Correia, 2009b).

3 La naturaleza del conocimiento y del ser humano para Humberto Maturana

Humberto Maturana junto con Francisco Varela ofrecen una explicación para el conocimiento a partir de la biología, esta visión tiene un impacto muy importante para el ser humano: el emerger de los fenómenos sociales y en particular para lo que quiero destacar en este texto, la educación en una perspectiva humanista. Gran parte de la teoría desarrollada por los dos autores, es ampliada por Maturana, y por ese motivo es que me refiero a él en este texto. Tradicionalmente las explicaciones sobre el conocimiento se centraban en una realidad única y perceptible, localizada fuera del sujeto que conoce. De esta vez, como biólogo y a partir de su experiencia en neurociencias, Maturana propone el conocimiento a partir de la perspectiva del conocedor. Explica que el conocimiento pasa por la experiencia del sujeto que conoce, esto es por la sensorialidad de los individuos y es leída e interpretada por el SNC. Maturana y Varela proponen que el Sistema Nervioso funciona en clausura

operacional, esto significa que este responde a aquello que puede sentir como estímulo, aquello que puede percibir en la experiencia. (Maturana & Varela, 1983).

Para Maturana el observador en su experiencia no consigue distinguir entre ilusión y percepción, pero puede producir explicaciones sobre su experiencia, que en la verdad son reformulaciones de la propia experiencia (Moreira, 2004). Para Silva e Infante-Malachias (2013) al reformular la experiencia en el lenguaje el observador va a interactuar con otro. Ahora, la forma como interactúa es un reflejo de su estructura cognitiva y neurológica, lo que le permite una diversidad de dinámicas (Maturana & Varela, 1983) para definir la forma como responde a los estímulos o de la manera por la cual formula sus proposiciones y explicaciones con respecto a aquello que aprende. Esto nos revela otro aforismo de Maturana que se muestra de gran importancia para la educación: “todo lo que es dicho es dicho por alguien”, la manera de percibir y comprender la realidad es única y delante de esta situación, la escuela no puede exigir que todos los niños o jóvenes realicen las mismas tareas, en los mismos tiempos de la misma forma.

Para esta discusión tomaremos también como fundamento teórico la propuesta de fenómeno social humano de Maturana, que se origina en la colaboración y el respeto por el otro. Para Maturana el fundamento de los fenómenos sociales es ético, esto significa que el fenómeno social humano está regido por la aceptación y el respeto por el otro como fundamento biológico de lo social (Maturana, 2001). Para Maturana este fundamento biológico es el amor que es un fenómeno biológico, una consecuencia evolutiva de la socialización y en este sentido la competición no es una relación social legítima, pues esta niega al otro. Para el autor el origen del *Homo sapiens* no se dio a través de la competición y si a través de la cooperación, y la colaboración – cooperación sólo puede surgir como una actividad espontánea a través de la mutua aceptación.

Para Maturana lo que nos torna humanos es nuestra particular manera de vivir juntos como seres sociales en el lenguaje, para él, el amor como fenómeno biológico nos permite huir de la alienación antisocial creada por el propio hombre a través de la racionalización. Concordo con Maturana al insistir en que es a través de la razón que justificamos la tiranía, la destrucción de la naturaleza o el abuso y la opresión de cualquier naturaleza sobre otros seres humanos. La cultura que vivimos constituye el medio en el cual somos realizados como seres humanos (Maturana, 2006), y esta puede ser la cultura de la aceptación o del rechazo.

4 Mapas conceptuales como instrumentos de formación y de inclusión en el aula

Mapas conceptuales fueron desarrollados por Novak en 1972 buscando resolver el problema presentado por la gran cantidad de respuestas obtenidas en una entrevista aplicada a estudiantes con el objetivo de comprender los cambios en la comprensión que los niños tenían sobre la ciencia (Novak & Cañas, 2010). Al darse cuenta de la dificultad para identificar y organizar esas informaciones, Novak elaboró un diagrama que permitía organizar gráficamente las informaciones y representar el conocimiento de un individuo sobre un determinado asunto.

Actualmente los mapas conceptuales son un poderoso instrumento de enseñanza, aprendizaje, evaluación, diagnóstico, captación de conocimiento experto, entre otros muchos proyectos disponibles en el sitio del propio Instituto para la Cognición Humana y Mecánica (*Institute for Human and Machine Cognition – IHMC*) que desarrolló el programa *CmapTools* (Cañas *et al.*, 2004b).

Algunos profesores no usan este instrumento por imaginar que gastarán mucho tiempo enseñando a sus alumnos a elaborar sus mapas, sin embargo, existen muchas e innovadoras iniciativas para formación de profesores de años iniciales, preescolares, enseñanza básica, media y superior. Muchos de estos profesores inician sus trabajos escolares con mapas conceptuales con niños no alfabetizados. Un ejemplo es el trabajo desarrollado por England *et al.* (2010) de la Universidad de Florida del Norte con profesoras de niños en edad preescolar (4 años) para aprender a usar y trabajar en sus grupos pre-escolares con mapas conceptuales.

Giombini (2006) trabajó con niños de 3 y 4 años a partir de una problemática observada por ella y destacada en su trabajo, ésta es el creciente porcentaje de dislexia junto con bajos niveles culturales que ha sido detectado en países occidentales más industrializados. De acuerdo con la autora, este hecho denuncia una difusa y alarmante incapacidad en la lectura cognitiva de la realidad relacionada a la propia cultura. Para Giombini (2006) el problema está en la falta de sincronización entre la forma del mundo (las cosas que nos rodean) y el modelo de acceso al mundo como es practicado y enseñado en la escuela. Para el profesor de la Universidad de Surrey, Ian Kinchin este modelo escolar es medieval y en la perspectiva de este texto, no posibilita la expresión ni el desarrollo ni el aprendizaje de los niños y jóvenes en la escuela.

Aquilino & Venditti (2006) desarrollaron un verdadero trabajo de integración sensorial en el aula utilizando mapas conceptuales con niños pequeños. Los niños en el trabajo presentado por las autoras durante el segundo encuentro de mapas conceptuales en San José en Costa Rica, trabajaron su sensorialidad con diversos materiales para elaborar sus mapas acerca de la fabricación del papel, inclusive utilizando su propio cuerpo acostados en el suelo. Al promover experiencias de aprendizaje, el uso de mapas conceptuales por los profesores en el aula favorece que todos sus estudiantes puedan expresar sus diferentes conocimientos y sus maneras diferentes de percibir el mundo a través de su sensorialidad y de aprender.

En casos de dificultades de aprendizaje o de socialización muchas veces vinculadas a trastornos de procesamiento sensorial que no son identificados por los adultos que conviven con los niños diariamente, el uso de mapas conceptuales en el aula, es una herramienta poderosa para favorecer acciones concebidas con intencionalidad para resolver problemas de otras formas. La manipulación de diferentes materiales estimula y favorece la utilización y sensibilización de diversos sistemas sensoriales, no apenas la audición como tradicionalmente en aula. De la misma forma, la elaboración de mapas conceptuales con diversos materiales favorece la creatividad y permite la expresión de las habilidades individuales y de grupo al trabajar colaborativamente en una misma sala y verdaderamente integrado al grupo.

La conciencia emerge de tales acciones (Momo et al. 2011b) en la relación y en el diálogo con otros, y al trabajar con diferentes objetos o materiales, comprendiendo y explicando en sus palabras las relaciones entre objetos, estas relaciones generan dinámicas inter e intra psicológicas, que permitirán que surjan nuevas formas de comunicación y de aprendizaje. En este sentido, la clase no necesitará ser “inclusiva” y si respetuosa. Respeto no impuesto de fuera para dentro, respeto por las propias habilidades, respeto por sí mismo y por los otros, porque desde el profesor y desde cada uno de los alumnos existirá la convicción que cada uno aprende de forma diferente pero que podemos colaborar al generar fenómenos sociales humanos (Maturana & Varela, 1983) para que el segundo nacimiento (Savater, 2006) sea realmente un dar a luz y no un aborto social, gestado desde y en la escuela.

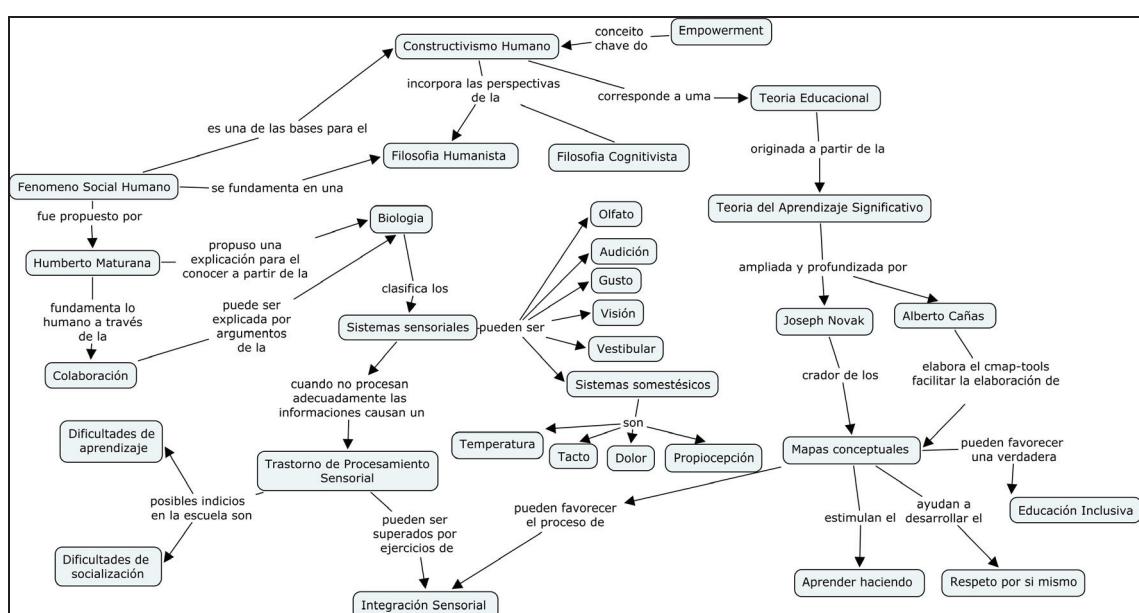


Figura 1. La primera versión de un mapa conceptual elaborado con el *cmap-tools* sobre los principales temas discutidos en este texto.

5 Consideraciones finales

Quisiera enfatizar aquí que de acuerdo con Moreira (1999) la filosofía humanista ve al individuo que aprende, primordialmente como persona. Lo importante es la realización de la persona, su crecimiento. El aprendiz es visto como un todo, pensamientos, sentimientos y acciones, como en la perspectiva del *Empowerment* de Novak. Para salir de la visión, en muchos casos medieval de la escuela, de acuerdo con Ian Kinchin, creo que es necesario ofrecer a los estudiantes verdaderas experiencias, una vez que para Maturana (2006), cada sujeto aprende y aprehende el mundo de acuerdo con su sistema nervioso y con su sensorialidad, de esta forma el conocer es siempre una reformulación de la experiencia, para ello necesitamos formar a los profesores para que puedan ofrecer a sus alumnos verdaderas experiencias. Para Maroni (2007), la sala de aula pocas veces

promueve verdaderas experiencias y no pocas veces tanto profesores quanto alumnos, principalmente aquellos alumnos con dificultades de aprendizaje o de socialización dejan la sala de aula heridos o indiferentes.

Recordamos que la UNESCO (2009b) indicó que es responsabilidad del sistema regular de cada país educar a todos los niños y, que esto exige modificaciones en el contenido, en los enfoques y en las estrategias utilizadas para la enseñanza. Como educadora pretendo con este texto divulgar el trabajo sensorial y colaborativo que puede ser promovido con el buen uso de los mapas conceptuales e insistir que su utilización en el aula para niños y jóvenes con dificultades de aprendizajes puede también cambiar y mejorar este panorama, y principalmente ofrecerles a ellos un feliz segundo nacimiento.

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DISEÑO, DESARROLLO Y VALIDACIÓN DE UN PROTOTIPO DE MATERIAL MULTIMEDIA EN FORMACIÓN OCUPACIONAL

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Resumen. El ámbito de la formación ocupacional es uno de los contextos educativos en que las TIC todavía está poco desarrollada y se basa en aspectos básicos de uso de Internet y paquetes de ofimática. En este trabajo se presenta el proceso de diseño, desarrollo y validación por parte de expertos, usuarios y formadores de un prototipo de material multimedia basado en mapas conceptuales como base para la organización de contenidos, que incluyen como recursos vídeos didácticos y material digital con texto, imágenes y códigos QR, para un curso de Auxiliar de carrocería en la Cooperativa Jovent, un centro de formación ocupacional de Mallorca (Islas Baleares, España). Este material es producto del trabajo conjunto entre la Cooperativa y el Grupo de Tecnología Educativa de la Universitat de les Illes Balears. Los resultados de la validación de los expertos, y usuarios y formadores del curso son muy positivos y apuntan a una mejora en los procesos de enseñanza-aprendizaje del proyecto en que se ha implementado el material multimedia. Sugieren mejoras en aspectos estéticos y de presentación de contenidos a través de los mapas, que se revisarán para la posterior generalización del material multimedia, adaptado para cada contexto, a todos los cursos de la institución.

Palabras claves: formación ocupacional; itinerario de aprendizaje; multimedia educativo

1 Introducción

La Cooperativa Jovent (<http://jovent.es/>), entidad sin ánimo de lucro dedicada a la formación ocupacional de jóvenes en riesgo de exclusión de Mallorca (Islas Baleares, España) desde 1991, está desarrollando actualmente un proceso de actualización y mejora de los procesos formativos y de gestión de la institución. En este proceso, la inclusión de las Tecnologías de la Información y de la Comunicación (TIC) se plantea como un objetivo prioritario, para lo que se estableció colaboración con el Grupo de Tecnología Educativa (GTE: <http://gte.uib.es>) de la Universitat de les Illes Balears (UIB), con el objetivo principal de diseñar una estrategia específica de integración de las TIC en la entidad (Lizana, Moreno, Salinas, & Rayó, 2013; Molina, Lizana & Salinas, 2013). Cabe destacar que en los centros de formación ocupacional, el uso de las TIC está todavía poco generalizado o se reduce a aspectos básicos de utilización de aplicaciones de ofimática e Internet (Aznar & Hinojoso, 2004).

El proyecto de integración TIC en Jovent presenta varias líneas estratégicas, una de las cuales es la creación de nuevos materiales didácticos a partir de los ya existentes, consistentes en fichas con texto e imágenes sobre procesos y materiales necesarios para llevar a cabo las tareas en los talleres ocupacionales, complementarios y de refuerzo a las explicaciones teóricas de los formadores de cada taller.

Este tipo de materiales didácticos se adapta a la metodología de trabajo en los cursos de formación ocupacional que ofrece la Cooperativa Jovent. La metodología en los talleres está basada en el trabajo por proyectos, de carácter individual. Esta metodología pretende combinar teoría y práctica a través de la realización de un proyecto centrado en problemas reales, a través del cual el usuario aplica la teoría resolviendo una situación posible (Cabero, Llorente & Salinas, 2006). Utilizando los materiales didácticos en formato de fichas, los alumnos pueden ir trabajando en los proyectos de manera autónoma y flexible en los talleres.

El proyecto de integración TIC se ocupa de diseñar y desarrollar materiales multimedia adaptados a las necesidades formativas y a la estrategia TIC general de la institución. Esto incluye, en primer lugar, evaluar el material didáctico existente para rediseñarlo teniendo en cuenta la metodología de trabajo de Jovent y aprovechando las posibilidades de las TIC, y, también, la validación por parte de los formadores y usuarios, que serán los beneficiarios directos de este cambio. Previamente a esta línea estratégica, cabe destacar que se llevó a cabo otra consistente en la adquisición de equipamiento e infraestructura tecnológica, como conexión por Wifi en la entidad, y la compra de una pizarra digital interactiva (PDI) y dispositivos móviles, en concreto tabletas, para poder hacer uso de los materiales didácticos tanto en las aulas donde se trabaja la formación teórica de los proyectos como en los talleres, donde se lleva a cabo la parte práctica.

En este trabajo se presenta el prototipo de material para un curso de formación ocupacional en auxiliar de carrocería, así como su validación por parte de expertos en creación de materiales didácticos y por parte de los usuarios y formadores del curso en que se implementa. Este curso de formación ocupacional tiene por nombre

completo "Operaciones auxiliares de mantenimiento electromecánico de vehículos" y una duración de dos meses, desde abril a junio del 2014, con un total de 270 horas y 40 horas prácticas en empresas. Este curso conduce a la obtención de una titulación: otorga el Certificado de Profesionalidad de nivel 1 emitido por el SOIB (Servicio de Ocupación del Gobierno de las Islas Baleares). Con este certificado, válido en todo el estado español, el usuario podría trabajar en cualquier empresa como aprendiz avanzado.

2 Marco de referencia

Una de las grandes posibilidades de las TIC radican en su capacidad de representar la información mediante contenido multimedia interactivo, es decir pudiendo converger e integrar distintos medios, como: texto, imágenes estáticas, vídeo, imágenes tridimensionales, sonidos, etc., y dotándolos de interactividad, flexibilizando así el acceso a la información por parte del usuario.

Otro aspecto esencial en cualquier proceso de enseñanza-aprendizaje es la estructuración y secuenciación de los contenidos y aprendizajes que debe lograr el alumno. Según Ausubel, Novak y Hanesian (1983) los organizadores previos son un material introductorio de mayor nivel de abstracción, generalidad e inclusividad que el nuevo material que se va a aprender. La función del organizador previo es proporcionar "andamiaje ideacional", servir de apoyo al alumno frente a la nueva información actuando de puente entre el conocimiento actual del alumno y el nuevo material.

Los mapas conceptuales se pueden utilizar como un método de organización y representación de la información, construyendo un entorno de navegación efectivo que ayuda a la recuperación de la información (Cañas, Ford, & Coffey, 1994; Cañas et al., 2000; Darder, de Benito, Escandell, & Salinas, 2006; Novak, 1998). Estos mapas, además de tener un gran potencial para utilizarse como organizadores y estructuradores del conocimiento, permiten incluir recursos que ayuden a describir con mayor acierto el concepto o idea indicado. Estos recursos pueden ser, por ejemplo, enlaces web, vídeos, documentos, etc.

Los mapas conceptuales pueden utilizarse como organizadores de la secuencia del aprendizaje en forma de itinerarios de aprendizaje (Cañas & Novak, 2010; De Benito, Cañas, Darder & Salinas, 2010; De Benito, Darder & Salinas, 2012). Según Darder, de Benito, Salinas, & Cañas (2010) los itinerarios de aprendizaje construidos sobre mapas conceptuales pueden caracterizarse por:

- Constituir un potente organizador tanto de los conceptos, temas, etc., a aprender, como de los objetos de aprendizaje a utilizar.
- Dar una visión completa de lo que debe hacerse para comprender el tema en cuestión.
- Ofrecer un sistema de navegación flexible: proporciona opciones o alternativas a seguir en la construcción de la propia secuencia de aprendizaje. El alumno ajusta la navegación a las características individuales (necesidades, estilo de aprendizaje, etc.).
- Proporciona control al alumno sobre la secuencia de aprendizaje.

La incorporación a dichos itinerarios de aprendizaje basados en mapas de recursos como enlaces web, vídeos, documentos, etc., incrementan el potencial de los mismos. El uso de vídeos en el aula, p.e., no es nuevo, pero sí es cierto que muchos vídeos que se han utilizado en las aulas no son propiamente vídeos didácticos, muchas veces se trata de documentales y programas televisivos que, a pesar de poder ser potencialmente educativos, no están diseñados para utilizarse directamente en un proceso de enseñanza y aprendizaje.

Por otro lado, la evolución de dispositivos, redes y aplicaciones web 2.0, está haciendo que cada vez sea más frecuente el uso de dispositivos móviles para acceder a todo tipo de información y gestiones, pudiéndose hablar en el ámbito educativo del "mobile learning" o "mlearning", una práctica cada vez más habitual gracias a la popularización de los *smartphones*, de las tabletas digitales, y otros dispositivos móviles (Camacho & Lara, 2011). El uso de estos dispositivos permite, cada vez más, un aprendizaje ubicuo, permitiendo el acceso a la información y los recursos en cualquier momento y lugar (Salinas, 2012). Asociado al uso de dispositivos móviles, se pueden mencionar los códigos QR (*Quick Response* - respuesta rápida) que consiste en un código de barras bidireccional que puede almacenar información muy diversa: mensajes de texto, direcciones de internet, coordenadas GPS, tarjetas de visita virtuales, etc. (Román-Graván, 2012). La utilización de los códigos QR se está popularizando en diferentes ámbitos sociales y comerciales, comenzando también explorarse sus posibilidades en el ámbito educativo, en el que pueden encontrarse diversas e interesantes experiencias (Ballesteros, Delgado, & Bernal, 2012; Casanova & Molina, 2013; Law & So, 2010).

Todas estas herramientas descritas ofrecen grandes posibilidades para la formación, y se encuentran todavía poco desarrolladas, sobre todo en combinación, y especialmente en el ámbito de la formación ocupacional. Por tanto, un material multimedia que aúne la potencialidad de los mapas conceptuales como organizadores del aprendizaje, de los vídeos didácticos para atraer la atención y transmitir la información de forma visual y auditiva, y el de los dispositivos móviles y los QR para permitir el acceso ubicuo y conectado, parece a priori una idea innovadora y con grandes posibilidades educativas.

3 Metodología

El procedimiento de trabajo para la creación del prototipo de material multimedia sigue la metodología de investigación y desarrollo (Reeves, Herrington, & Oliver, 2004; Reeves, 2000, 2006), que aúna teoría y práctica educativa, por considerarse la más adecuada teniendo en cuenta las características y objetivos del proyecto. Lo que verdaderamente la caracteriza de acuerdo con Reeves (2006) es ser participativa, colaborativa, desde el momento en que en el proceso se adopta un proyecto de grupo, por lo que el sistema de trabajo es básicamente colaborativo, tanto entre el equipo de investigadores, como entre estos y los expertos externos, en su caso.

A lo largo del desarrollo del prototipo se han dado varios ciclos iterativos de análisis de necesidades, toma de decisiones, desarrollo de propuestas y valoración de las mismas (Wang & Hannafin, 2005), hasta llegar al prototipo que se presenta y que, a su vez, presentará iteraciones para su mejora a través de su validación.

Para la elaboración del prototipo se partió del material actual del Curso de Auxiliar de Carrocería impartido en Jovent que tiene el formato de fichas de trabajo. De este curso se seleccionaron dos proyectos que lo componen: 'Preparación de superficies' y 'Enmascarado'. El diseño y desarrollo de un nuevo material didáctico pretende aprovechar las posibilidades de las tecnologías digitales, de la organización de materiales en mapas conceptuales y de las ventajas de utilización de tablets y otros dispositivos móviles.

4 Diseño y desarrollo del prototipo

En las distintas fases del proceso de diseño y desarrollo del material, se llevaron a cabo varias sesiones de trabajo presenciales y en línea entre los miembros del equipo del GTE y los de Jovent, para la toma de decisiones que implican el trabajo colaborativo en el producto resultante.

En concreto, se llevó a cabo una revisión del material con el que trabajaban los alumnos (las fichas), para familiarizarse con el contenido e identificar los aspectos clave de la formación. Así mismo, se realizaron visitas al centro y reuniones con el formador del curso para el que se iba a diseñar el prototipo y con el responsable de la entidad. Tras el análisis inicial y la valoración de diferentes aspectos del material existente, de la metodología docente y de los recursos tecnológicos disponibles, se realizó un estudio de posibilidades y se concretó una propuesta de prototipo de material multimedia interactivo. Esta propuesta se integra en la estrategia general del proyecto, en sinergia con las dinámicas formativas de los cursos y se desarrolla en coherencia con la nueva infraestructura tecnológica que se está implementando en la entidad.

El diseño de este material, se orienta a favorecer el acceso al contenido de forma individualizada, en diferentes situaciones, tanto en el aula como en el taller de práctica, pudiéndolo consultar tanto mediante dispositivos móviles como a través de ordenadores. Por tanto, se explotan las posibilidades para el trabajo individual y autónomo que ofrece el uso de material multimedia con dispositivos móviles, dentro y fuera del aula (Camacho & Lara, 2011).

El prototipo desarrollado se compone de varios tipos de recursos, que se integran y complementan entre sí (Lizana, Moreno, Salinas & Rayó, 2013b):

4.1 Mapas conceptuales como organizadores del contenido y base del material

Se presentan diversos mapas conceptuales que actúan como organizadores del contenido formando itinerarios de aprendizaje flexibles. Estos mapas han sido elaborados con el software CmapTools y constituyen la base del material multimedia presentado para el desarrollo de los proyectos por parte de los alumnos.

El núcleo del material multimedia consiste en tres mapas conceptuales, uno inicial (Fig. 1) y los otros dos referentes a cada uno de los Proyectos (Fig. 2) que llevarán a cabo en módulo formativo 3 "Técnicas básicas de reparación de superficies" del certificado de profesionalidad "Operaciones auxiliares de mantenimiento de carrocerías de vehículos".

El mapa conceptual presenta la estructura y secuencia del proyecto a desarrollar y a partir del mismo accede a distintos materiales complementarios como pueden ser fichas, secuencias en vídeo, etc. (Fig. 2). El uso habitual por parte de los alumnos es a través de navegador, y se aprovechan así las posibilidades de interacción que ofrece este formato: los usuarios pueden acceder a los diferentes recursos enlazados, ya sean externos, ya diseñados expresamente como parte del prototipo (vídeos y fichas en pdf), ya existentes en los materiales iniciales de los talleres o aportados por el formador del curso (imágenes y documentos pdf).

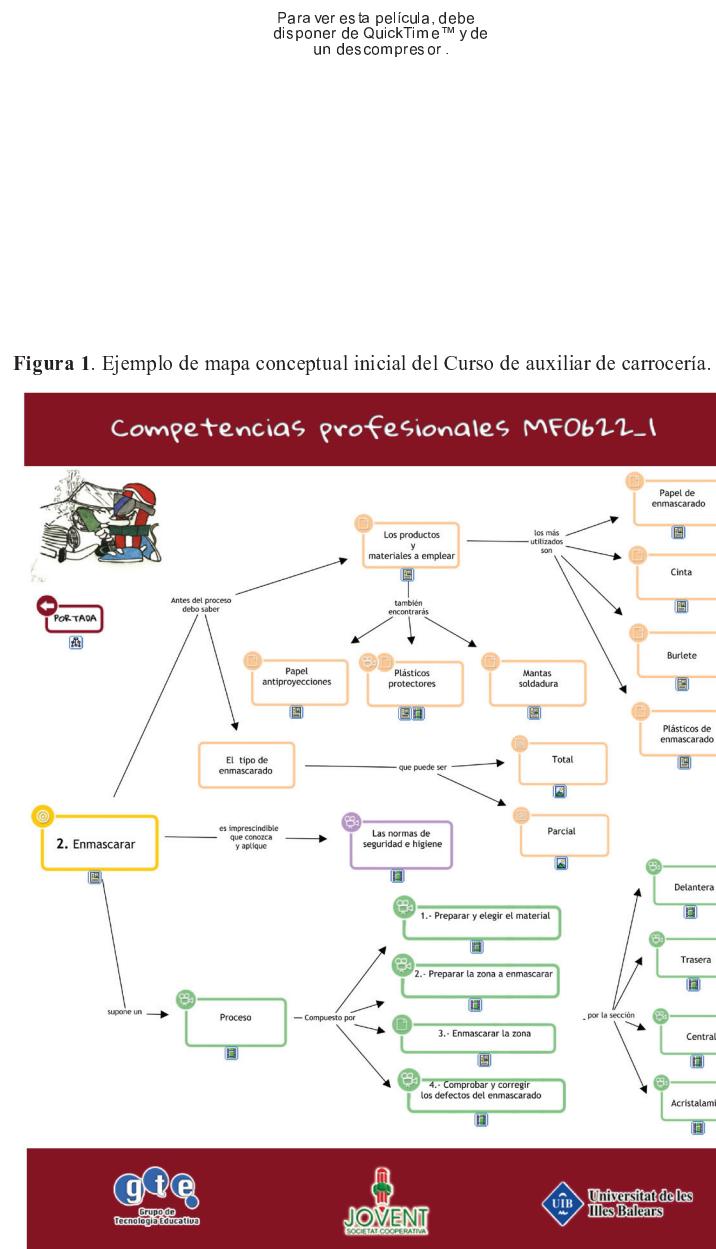


Figura 1. Ejemplo de mapa conceptual inicial del Curso de auxiliar de carrocería.

Estos mapas, juntamente con los recursos enlazados que contienen, se copiaron en las tabletas para su acceso sin conexión, de forma que la descarga del material multimedia de uso frecuente no fuera un impedimento para su consulta inmediata en caso de dudas.

4.2 Vídeos didácticos

Una de las carencias expresadas por los formadores en el análisis de necesidades fue la escasez de recursos audiovisuales que ayudasen a mostrar y explicar algunos procesos prácticos de los proyectos que se desarrollan en los talleres, los que generan más dudas entre los alumnos. Partiendo de esta necesidad manifiesta, se planteó el desarrollo de vídeos didácticos específicos para cada proyecto. Los vídeos han sido creados ad hoc para adaptarse a las necesidades y contenidos del proyecto, y se centran en la realización y explicación de diferentes procedimientos prácticos por parte del formador (Fig. 2). Estos vídeos se encuentran enlazados como recursos en los conceptos correspondientes del mapa conceptual, aunque también están enlazados mediante un código QR en los carteles didácticos diseñados para el taller, como se describe más adelante. Este enlace a través de QR apunta a vídeos subidos a Vimeo con contraseña de acceso, para así facilitar su visualización en streaming a través de las tabletas y evitar problemas por su descarga.

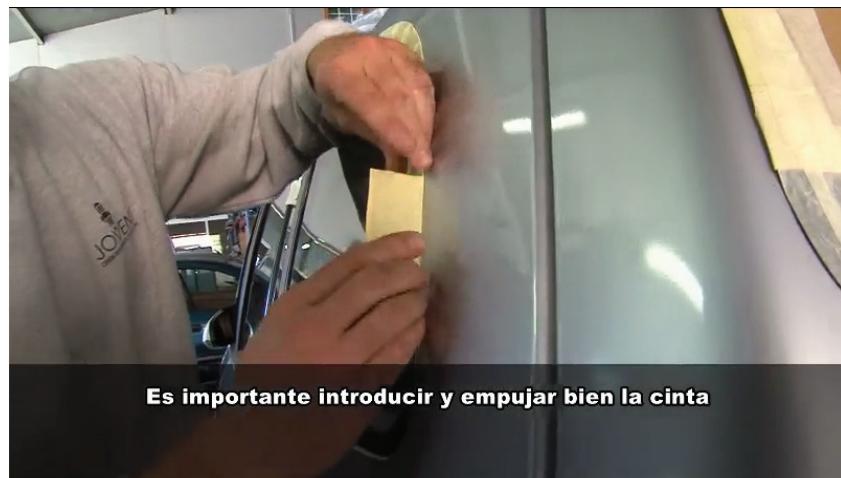


Figura 2. Captura de pantalla de uno de los vídeos didácticos.

El proceso de planificación, grabación y edición de los vídeos didácticos, se llevó a cabo en coordinación y supervisión constante entre el equipo técnico del GTE, el formador del curso, otros miembros de Jovent y técnicos profesionales de grabación y edición, para garantizar así la adecuación de los productos finales al modelo planteado y su calidad.

4.3 Nuevos materiales impresos

El prototipo incluye el rediseño de los materiales ya existentes (fichas en pdf), lo que ha conducido a la creación de nuevos materiales impresos, siguiendo la estética del resto del prototipo (Fig. 3).

4.4 Cartelería didáctica para el taller

Para favorecer el acceso a los recursos multimedia desde el taller donde se realizan las prácticas, se diseñaron una serie de carteles. De esta manera, los alumnos pueden consultar los distintos contenidos multimedia del curso enlazados a los QR mediante dispositivos móviles a través de la conexión inalámbrica del centro (Fig. 4).

El material ofrece distintas posibilidades de uso, ya que ha sido diseñado para que pueda ser utilizado adaptándose, tanto al aula como a los talleres.

En el aula, el material tanto puede ser proyectado por el formador para realizar explicaciones generales, como utilizado individualmente por los alumnos en las tabletas.

En el taller, los alumnos pueden acceder de forma ágil a los contenidos multimedia mediante las tabletas empleando la cartelería dispuesta que contiene esquemas de los procesos prácticos a realizar, y que enlazan mediante códigos QR a los vídeos explicativos.

Antes de pasar a la fase de validación, se llevó a cabo una primera valoración por parte del equipo de trabajo de la institución, que resultó positiva y sirvió para redefinir y optimizar el proceso de trabajo a seguir. También, previamente al proceso de validación, se realizaron sesiones formativas en el uso de los recursos tecnológicos implicados en la utilización del prototipo, para la correcta implementación de los materiales

diseñados. Específicamente, se trabajó con el software Cmaptools para el uso adecuado de los mapas conceptuales del prototipo, así como con las tabletas para su manejo y uso básico del material multimedia y las aplicaciones implicadas en su uso (navegador web, reproductor de vídeo, lector de pdf,...).



Figura 3. Material impreso y código QR en uno de los carteles didácticos.

5 Proceso de validación

La fase de validación del prototipo de material multimedia descrito en parte está actualmente en proceso. Se han contemplado tres tipos de validación:

- por parte de expertos en creación de material didáctico multimedia,
- por parte de los usuarios de Jovent que lo utilizan en el curso
- y por parte de los formadores del curso

Para garantizar la calidad, tanto técnica como pedagógica del material multimedia, se realizó la validación por parte de tres expertos en material multimedia educativo. El instrumento para realizar esta validación consistió en un cuestionario con escala Likert a través del cual se plantearon una serie de ítems, donde se valoraba el grado de acuerdo y desacuerdo. El cuestionario se estructuró en torno a cinco dimensiones: diseño (6 ítems), estética (5 ítems), contenidos (6 ítems), navegación del mapa conceptual (5 ítems) y originalidad (1 ítem). El total de afirmaciones a valorar por parte de los expertos era 23.

Al final de cada dimensión, el cuestionario disponía de un espacio para que los expertos aportaran al menos dos aspectos de mejora para el material multimedia. Para proceder con la validación se proporcionó a los expertos una tableta con todo el material multimedia preparado, tal como se lo iban a encontrar los usuarios y formadores de Jovent en el momento de su implementación en el curso.

Una vez validado el material por parte de los expertos (indicados con E de experto) se obtuvieron los siguientes resultados de acuerdo a cada dimensión. Las valoraciones por parte de los expertos son en general bastante positivas (84,42 sobre 100 para la valoración global, siendo para diseño, 77,75; estética 76,65; contenidos 95,83; navegación del mapa conceptual 86,65, y originalidad 83,25). Indican algunos aspectos que podrían ser mejorables, como por ejemplo la estética (dimensión en la cual las puntuaciones son más bajas para todos los expertos).

Respecto a la validación por parte de los usuarios de Jovent, se realizó a través de un cuestionario anónimo y opcional suministrado vía online de escala Likert (Totalmente en desacuerdo a Totalmente de acuerdo) que contemplaba 33 preguntas sobre la valoración del uso del material multimedia agrupadas en 9 categorías: Datos generales, Adaptación a las características individuales de los destinatarios, Contenidos, Metodología, Navegación, Funcionalidad, Velocidad de carga, Nivel de interactividad, Diseño y Estética del material. Aparte se incluye un apartado de comentarios para incluir aspectos a mejorar o sugerencias. Participaron 13 de los usuarios, de género masculino. En general, las valoraciones son muy positivas, consideran que es un buen recurso para aprender y aunque era la primera vez que utilizaban un mapa conceptual multimedia, consideraron que había sido fácil su navegación, así como también el acceso a los recursos. La información les fue fácil de localizar dentro de los mapas conceptuales, aunque indican algunos aspectos de mejora, relacionados con la inclusión de algunos contenidos que faltan y la estética del material multimedia en relación al tamaño de letra (en el caso del mapa) y el volumen (vídeos). Además del cuestionario, se realizó una entrevista colectiva con los usuarios, donde se observó que la mayoría de ellos prefirió utilizar el material multimedia en vez del impreso, y destacaron la mayor rapidez y comprensión de los contenidos y procesos a partir de este material y su facilidad de navegación y acceso a los recursos. Como sugerencia proponen la creación de materiales multimedia también para otros proyectos.

En relación a la validación por parte de los formadores del curso en Jovent, se realizó a través de una entrevista conjunta. El guión de la entrevista incluía preguntas sobre la valoración del uso del material multimedia como: Adaptación a los destinatarios, Adaptación a los objetivos de los proyectos, Contenidos del material, Valoración de los recursos y material multimedia, y Sugerencias o aspectos a mejorar. Los formadores valoran positivamente el material en tanto que está adaptado a los usuarios y al nivel del curso, denotan mejoras en el aprendizaje de los usuarios especialmente en términos de rapidez y comprensión, es fácil de utilizar, es atractivo y motivador, y se adapta a los objetivos de los proyectos aunque conviene mejorar algunos aspectos en relación a los contenidos. Como aspectos a mejorar inciden en la creación de algún espacio de comunicación participativo con los usuarios y la protección de los vídeos del material mediante la restricción de acceso y la inserción de marcas de agua.

6 Conclusiones

El proceso de validación muestra resultados positivos por parte de los expertos, así como también por parte de los formadores y usuarios que han participado en el curso de auxiliar de carrocería donde se ha implementado el prototipo de material multimedia.

El producto resultante es un material de calidad e innovador, que resulta motivante y atractivo para este tipo de formación ocupacional y, en concreto, para los usuarios de Jovent, y práctico para los formadores. El proceso de validación por parte de usuarios y formadores apunta a que el material es bastante válido para este tipo de formación.

La organización de las secuencias de aprendizaje en itinerarios basados en mapas conceptuales resulta adecuada para este tipo de aprendizajes predominantemente de tipo procedimental.

Una vez incorporadas las mejoras sugeridas y rectificadas las deficiencias detectadas, el siguiente paso lógico, revisados los resultados satisfactorios que ha dado esta primera implementación, se procederá de forma gradual a la generalización al resto de cursos siguiendo el mismo formato del prototipo, incluyendo los cambios necesarios para su adaptación al contexto concreto de cada curso.

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EL USO DEL MAPA CONCEPTUAL PARA LA COMPRENSIÓN DE TEXTOS

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Resumen. En este trabajo se describen las formas en que los alumnos universitarios representan mediante mapas conceptuales su comprensión de los textos. En algunos casos se observa que el mapa conceptual no es integrado a las estrategias de comprensión perdiendo con ello su función de mediación en la interpretación del texto, esto es, mediando el proceso de aprendizaje al ayudar a relacionar y recuperar el conocimiento previo con la información nueva. Se describen en detalle las estrategias de simulación para cumplir con el mapa conceptual. También se analiza un caso en el que el mapa conceptual sirve a la mediación donde puede observarse como la reconstrucción de la jerarquía disciplinaria ocurre como una expresión personal del sujeto.

Palabras Clave: Unidad de significado textual, unidad de significado síntesis, estrategias de simulación, sentido del mapa conceptual, narración.

1 Introducción

El presente artículo es un continuo de las investigaciones desarrolladas con un grupo de trabajo sobre el uso del mapa conceptual principalmente en las ciencias sociales a nivel universitario. Se describen las maneras en que los alumnos de educación superior utilizan los mapas conceptuales cuando deben representar conceptos producto del aprendizaje basado en la lectura particularmente en el dominio del conocimiento de la ciencia política. Se enfoca de manera crítica a los casos no exitosos en la apropiación del mapa conceptual como una herramienta para el aprendizaje.

Se parte de considerar de una manera novedosa al mapa conceptual, la primera de ellas tiene que ver con que la jerarquía puede ser establecida desde el punto de vista de una narrativa (Padilla Arroyo, Aguilar Tamayo, y Cuenca, 2006). La segunda consiste en que si bien un mapa conceptual puede presentar deficiencias técnicas, éste puede ser interpretado, lo que permite dotarle de sentido (Aguilar Tamayo, 2004). La narrativa en el mapa conceptual también puede ser utilizada de una manera engañosa, este caso se presenta cuando los estudiantes de nivel superior deciden apropiarse de la estructura lineal de un texto para representarla en un mapa conceptual sin que ello implique un proceso de aprendizaje.

2 Jerarquización y narración en el mapa conceptual

La proposición es un elemento importante para el aprendizaje significativo, ésta es la unión de una serie de conceptos que forman un enunciado, regularmente de tipo afirmativo, sobre un acontecimiento o un objeto. La forma en que se enuncia el conocimiento es mediante proposiciones acerca de las cosas, fenómenos y problemas, por esta razón, la elaboración-construcción de proposiciones se puede considerar un producto del pensamiento que refleja, entre otras cosas, una comprensión sobre el mundo (Novak, 1998). La perspectiva de Ausubel (2002; Novak, 1998) brinda el sustento teórico para comprender la importancia de la proposición, ésta es resultado de un proceso de aprendizaje significativo, lo que explicaría por qué un sujeto que comprende o domina un tema/concepto, puede expresarlo de distintas maneras, a diferencia de una definición que es aprendida de memoria. La construcción de proposiciones personales es un indicador de comprensión, el uso o re-uso de expresiones proposicionales con poca reelaboración o de limitada flexibilidad para su uso en otros contextos pueden indicar una comprensión limitada o un aprendizaje memorístico.

Las proposiciones pueden analizarse desde varias perspectivas, una de ellas es la técnica del mapa conceptual, lo que implica considerar si los conceptos presentados son relevantes, si se repiten, si hay oraciones completas consideradas como conceptos, o el uso de éstos como palabras enlace. Una segunda perspectiva evalúa la validez de la proposición, algunos de los elementos que sirven de guía son las preguntas de enfoque, los dominios del conocimiento o el conocimiento de los expertos. Para el presente artículo se considera que la validez de una proposición estaría determinada por el texto que leen los alumnos y que sirve de base para elaborar el mapa conceptual. En cierto sentido los textos son una manera en que se difunden los dominios del conocimiento. Las proposiciones también pueden analizarse desde el punto de vista de las coincidencias que

muestran en relación con el texto que sirve de base al mapa conceptual, donde lo que se busca es detectar si hay una apropiación o no de la estructura lineal del texto (Manzano & Aguilar Tamayo, 2012). Como puede deducirse, los textos que leen los estudiantes son la base para determinar si hay o no una apropiación de su estructura lineal o para determinar la validez o no de las proposiciones.

Una última aproximación a las proposiciones tiene que ver con los conceptos que se incluyen y se organizan de manera jerárquica de acuerdo a un dominio de conocimiento y/o en relación a una pregunta de enfoque. Los conceptos más inclusivos se ubican en la parte superior del plano y los menos inclusivos en los niveles inferiores (Novak, 1998; Novak & Cañas, 2006; Novak & Gowin, 1988). La jerarquía se relaciona con la generalidad o grado de abstracción de un concepto con referencia a un dominio de conocimiento, su representación en el mapa conceptual conjuga el elemento espacial, es decir, la posición en un plano, junto con las relaciones semánticas que pueden expresar subordinación y que dan flexibilidad al aspecto espacial (Aguilar Tamayo, 2005).

Otros análisis muestran que la jerarquía puede establecerse de otra manera, dependiente en mayor medida de la semántica y por estructuras más generales, tal es el caso de la narración, que es un elemento organizador del mapa conceptual sobre todo en disciplinas como la historia (Padilla Arroyo et al., 2006). El concepto de narración es un elemento para el análisis del mapa conceptual que pone el acento en las *líneas narrativas* y que tiene como unidad básica de análisis a las *proposiciones*. El análisis por líneas narrativas ayuda a la comprensión del sentido del mapa conceptual, éste se constituye por un proceso de interpretación que implicaría algo más que la suma de proposiciones. Sin embargo, debe distinguirse entre las posibilidades del mapa conceptual para la representación de la *narración* o de esta como elemento organizador, y la *intención* de hacer tal representación.

3 Encontrando el sentido al mapa conceptual

El análisis del mapa conceptual para el presente artículo considera que aun cuando puede ser deficiente desde el punto de vista de la técnica, puede ser leído e interpretado, lo cual permite brindarle de un sentido. Esta manera de aproximarse al mapa conceptual es resultado de considerarlo un artefacto cultural (Aguilar Tamayo, 2006), o como un texto a interpretar (Aguilar Tamayo, 2004). En estas perspectivas el mapa conceptual es separado analíticamente de su andamiaje teórico novakiano para verlo como un sistema de representación que puede “comunicar y representar conocimiento y que su estructura proposicional, junto con el uso de símbolos culturales, permiten darle una estructura que lo dotan de *sentido* y lo configuran como texto” (Aguilar Tamayo, 2005, p. 6).

Para dotarlo de sentido su interpretación tiene que pasar por alto ciertos aspectos que no son importantes para el sentido del mapa-texto, por ejemplo, un error de ortografía o tipográfico, o una proposición confusa. Este procedimiento implica negociar constantemente entre los formalismos del mapa conceptual cuyo uso-ausencia forman parte de los aspectos a interpretar, así como rebasar el aspecto técnico para poder evaluar y comparar si esta representación se acerca o difiere de aquello que representa. Es una tensión que busca aprehender la comprensión del sujeto y saber si ésta corresponde, en el caso del presente artículo, al sentido del texto sobre el cual se elabora un mapa conceptual.

Considerar al mapa conceptual como una herramienta cultural , significa que su elaboración, por parte de los estudiantes, puede entenderse como un proceso de apropiación y resistencia (Wertsch, 1999). Dicho proceso implica un aprendizaje donde su uso y función cambia cualitativamente de acuerdo a un sistema de actividad. La apropiación y resistencia al aprendizaje de la técnica del mapa conceptual y de su valor como artefacto mediador del aprendizaje puede observarse en la calidad o cualidad del mapa conceptual, en la actitud del alumno con respecto a éste y en la aplicación de la técnica en otras actividades de aprendizaje, entre otros. La resistencia al uso de herramientas culturales adquiere formas o estrategias específicas de acuerdo a la herramienta, Aguilar Tamayo y colaboradores (Aguilar Tamayo, García Ponce de León, Montero Hernández, y Cuenca Almazán, 2012), han descrito una de las estrategias utilizadas por los alumnos en educación superior en este proceso de apropiación. Dicha estrategia consiste en desplazar la tarea de reconstruir la jerarquía de los conceptos para tomar la jerarquía del texto con base en el cual se elabora el mapa conceptual, es decir, el alumno hace uso de la narración para jerarquizar los conceptos representados en el mapa conceptual sin que haya habido un proceso de aprendizaje forzosamente.

4 La metodología

4.1 El modelo didáctico de la clase

Los datos para la investigación se obtuvieron de un grupo de estudiantes de licenciatura en una universidad pública de la Ciudad de México. Uno de los autores participó como profesor de la asignatura ante dicho grupo. El nombre de la asignatura es Teoría de la Administración Pública, es de carácter teórico y su objetivo principal es reflexionar sobre los elementos epistemológicos y conceptuales que coinciden en la construcción de la administración pública como una ciencia con su metodología propia. La duración del curso fue de cuatro meses, la asignatura se impartía cuatro horas a la semana repartida en dos clases de dos horas cada una, lo que da un total de 32 clases. En la primera sesión se comentó que vía correo electrónico se les enviaría el programa, por lo que quienes decidieran cursar la asignatura deberían llegar a la siguiente clase con una copia del mismo pues se haría una lectura y explicación detallada. Así fue como durante la segunda clase se hizo la presentación de la asignatura y se leyó en su totalidad el programa.

La estrategia didáctica y de aprendizaje se basó en el análisis de textos mediante la elaboración de mapas conceptuales. Se planteó un modelo didáctico que propiciaba la lectura de un conjunto de textos, discusiones grupales y otras actividades; como parte central de éstas, se solicitó a los alumnos realizar por lo menos un mapa conceptual con base en cada una de las lecturas. Otros elementos para la evaluación del curso fueron la realización de una carpeta donde todos los mapas conceptuales tenían que ser recolectados, de un diario de clase y de un ensayo final.

Se indicó que todos los mapas conceptuales serían revisados al menos una vez, esto con el fin de que los alumnos contaran con dos o más versiones de su mapa conceptual y para ayudar a un mejor dominio de la técnica, lo que redundaría en una mayor confiabilidad en los datos recogidos. Para la adquisición de la técnica, especialmente durante las primeras clases se fomentaron distintas dinámicas tales como: la elaboración individual, la elaboración colectiva exclusiva de los alumnos y la elaboración colectiva que incluyera al docente, de manera constante se revisaban los mapas conceptuales. Se animó a los alumnos a elaborar sus mapas conceptuales en el programa informático CmapTools (IHMC, 2014) y a que entregaran tanto una versión electrónica como en impreso, algunos fueron elaborados a mano o con otro tipo de programa para computadora. Algunos mapas conceptuales tuvieron que ser escaneados al no contarse con su versión electrónica, esto es importante pues el análisis cualitativo de éstos se llevó a cabo mediante el programa informático Atlas.ti (ATLAS.ti GmbH, 2014). Para el proceso de comparación entre los mapas conceptuales y los textos utilizados, estos fueron convertidos al formato PDF para su análisis en Atlas.ti.

Todos los mapas conceptuales fueron recopilados mediante la estrategia de carpeta de aprendizaje (Colén, Giné, & Imbernon, 2006). Dados los problemas que se tuvieron para recolectar los datos, fueron muy pocos los mapas conceptuales que tuvieron una segunda o tercera versión. Las carpetas se entregaron al final del curso, en este escenario fueron uno de los elementos para la evaluación del alumno, por otra parte, para fines de la investigación esta se constituyó en los datos a analizar.

Igualmente, al inicio del curso se solicitó la escritura de diarios de clase, éstos originalmente se concibieron como un instrumento que permitiría una interacción con los alumnos distinta a la que normalmente se lleva a cabo durante las clases. También tenían como objetivo que se pudiera *tomar el pulso* al grupo, obtener una retroalimentación, que los procesos exitosos pudieran ser repetidos y los procesos poco o nada satisfactorios pudieran ser eliminados o corregidos. Se instruyó que en los diarios de clase debería quedar asentado el sentir del alumno con respecto a la clase, se pidió que escribieran si ésta era de su agrado o no y por qué, su opinión respecto a los contenidos de la materia, respecto a las lecturas a realizar, sobre la dinámica de la clase, la utilización de mapas conceptuales, sobre el uso de CmapTools, y se animó a dar sugerencias para mejorar el desarrollo de la clase. Interesaba particularmente su opinión con respecto al uso del mapa conceptual, tanto como un instrumento que permitiría su participación, como de evaluación. Se pidió a los alumnos que escribieran en el diario clase tras clase, éstos serían revisados al menos en una ocasión durante el curso.

Conforme transcurrían las sesiones, la resistencia para trabajar con los mapas conceptuales se expresó en actitudes negativas, ausencias y comentarios por parte de los estudiantes. Menos de la mitad del grupo elaboraba sus mapas conceptuales, había quienes además de no elaborarlo, tampoco realizaban la lectura correspondiente. Quienes sí los construían eran, en la mayoría de los casos, un reducido número de alumnos. Pocos alumnos solicitaron una segunda revisión de su mapa conceptual, y ninguno dio evidencia de realizar una tercera versión. Dadas las actitudes de gran resistencia por parte de los alumnos para utilizar el mapa conceptual, el profesor que estuvo frente al grupo se vio en la necesidad de rediseñar la estrategia de recolección que originalmente se

propuso, principalmente porque las actividades didácticas que apoyaban el desarrollo del curso fueron realizadas con escasa participación y en algunos casos no se pudieron desarrollar. Se considera que la consistencia de los datos que se analizan no se encuentra comprometida, sin embargo limita una exploración diversa o profunda a partir de esta experiencia, por lo que las nuevas preguntas y problemáticas que se han originado implicará en un futuro una nueva recolección de datos. En lo que hace al contexto de las actividades de clase, también se hace necesario organizarlas de una manera distinta, un ejemplo de ello pueden ser las reflexiones didácticas sugeridas por Tifi (2010). La resistencia al uso del mapa conceptual, saca nuevamente a la luz la necesidad de reflexionar críticamente sobre una didáctica del mapa conceptual.

La confiabilidad de los datos estaría sustentada en varias razones. Dado que las primeras sesiones del curso se orientaron a la enseñanza y reforzamiento de la técnica del mapa conceptual, se considera que esto permite concebir a los mapas conceptuales recolectados como representaciones estables, que siguen más o menos las convenciones de la técnica, particularmente ofrece elementos para la inferencia sobre la comprensión del sujeto respecto a un texto determinado. Igualmente se asume que la validez y consistencia de los datos se constituye por el hecho de que los alumnos cuyas carpetas se analizaron, estaban todos ellos inscritos, por lo cual recibieron instrucciones claras y concretas sobre cómo elaborar los mapas conceptuales además de revisarlos a lo largo del semestre con el fin de facilitar y reforzar sus procesos de elaboración. Otro aspecto fue que los mapas conceptuales a la par de otros trabajos se constituyeron en las evidencias de aprendizaje para emitir una evaluación final, por ello, los alumnos que cursaron la asignatura tenían motivos para cumplir con el requisito de entregar la carpeta.

Las características de los mapas conceptuales contenidos en las carpetas permiten clasificarlas en tres tipos diferentes: original, copia y original-copia. Las carpetas Original contienen mapas conceptuales producto del trabajo individual del alumno, son mapas conceptuales originales porque no son copia de los revisados en clase o de algún compañero. Las carpetas Copia refieren a mapas conceptuales que en realidad son copias de otros, pueden ser de dos tipos, las primeras son copia de los mapas conceptuales revisados y reelaborados en clase, mientras que las segundas son copia de algún compañero. Finalmente las Original-copia son carpetas que contienen ambos tipos de mapas conceptuales (ver Tabla 1).

Tabla 1: Características de las carpetas entregadas por los alumnos al final del curso.

Tipo de carpeta	Características
Original	La mayoría de los mapas conceptuales que integran la carpeta del alumno son productos de su trabajo individual.
Copia	La mayoría de los mapas conceptuales que integran la carpeta son copias de otros mapas. - Tipo A - Son copia de los mapas conceptuales revisados y reelaborados en clase. - Son copia de los mapas conceptuales de algún compañero
Original-copia	La mayoría de los mapas conceptuales que integran el portafolio pueden ser de los dos tipos considerados anteriormente.

5 Los textos utilizados

Los mapas conceptuales analizados son resultado de la lectura de cuatro textos. Deben considerarse dos momentos para la selección de las lecturas y del análisis de los mapas conceptuales. El primero tiene que ver con las lecturas y se relaciona con la situación pedagógica por la cual atraviesa el alumno, esto significa que el manejo de las lecturas y de los conceptos va de lo sencillo a lo complejo. El segundo tiene que ver el aprendizaje del mapa conceptual, que va de una elaboración sencilla y deficiente a una más compleja y abstracta.

El primero (Emmerich, 1997), es un libro elaborado como material didáctico para estudiantes universitarios de ciencia política, es de tipo teórico y presenta los dilemas metodológicos de la ciencia política, el capítulo analizado ofrece una breve síntesis de los modelos de conocimiento. Es un texto que contiene figuras, tablas, guías de lectura, comentarios al final de cada capítulo y referencias bibliográficas, dada su exposición y desarrollo puede ser considerado como de fácil comprensión. Su pertinencia reside en que uno de los temas a manear en la teoría de la administración pública es aquel que se relaciona con la construcción científica o no de dicha disciplina, de aquí que la asignatura inicie reflexionando sobre el sujeto de conocimiento, el objeto de conocimiento y la relación de conocimiento. La problematización de estos tres conceptos permite construir 4 modelos del conocimiento: a) el realista ingenuo, b) el idealista simple, c) el idealista-trascendental y d) la teoría de la praxis. Lo que se esperaba de los alumnos era un mapa conceptual sobre los modelos del conocimiento, o

uno para cada modelo, donde debían figurar los conceptos de sujeto, objeto y relación del conocimiento. Para efectos del presente artículo nos centraremos solamente en este texto.

La selección de esta lectura obedece a que el alumno está situado didácticamente al inicio del curso, la lectura utiliza un discurso conceptual sencillo, asequible para quienes inician sus estudios universitarios. Es una lectura de tipo metodológico que brindará las herramientas para conocer las perspectivas teóricas desde las cuáles pueden ser situados los demás autores. En cuanto al aprendizaje del mapa conceptual, el alumno está en sus inicios, este es el segundo que elaboran y será considerado ya formalmente tanto para la evaluación como para la investigación. Planteado como pregunta, este mapa conceptual con su respectiva lectura ha sido elegido para saber ¿cómo son esos primeros mapas conceptuales?, ¿qué muestran?, ¿qué mapea el alumno?, ¿qué conceptos aparecen y cuáles no?

Los siguientes tres textos no fueron escritos específicamente como textos universitarios. El primero de ellos (Aguilar Villanueva, 1998) es un artículo publicado en una revista especializada y forma parte de una antología de textos de la materia, se le considera teóricamente como el más complejo y abstracto. El segundo (Bobbio, 2005) es una selección de escritos ordenados de manera que se presentan como una teoría general de la política, es un texto teórico de mediana complejidad. El último texto (Sánchez González, 2001) se presenta como una serie de razonamientos en torno a la científicidad de la administración pública, forma parte del programa de la asignatura como una lectura obligatoria, también se le considera un texto de mediana complejidad.

6 El análisis de los mapas conceptuales

Las propuestas conceptuales junto con el análisis de los mapas conceptuales particularmente de las proposiciones, han permitido la construcción de un concepto al que se ha denominado Unidad de significado. Así como se ha convertido al mapa conceptual en unidades de análisis más pequeñas hasta llegar a las Unidades de significado, fue necesario descomponer al texto en unidades de análisis similares, se ha establecido al Párrafo (Serafini, 1991, 1996) como la unidad que permitirá encontrar relaciones significativas entre ambas unidades.

Con base en Novak (1998; Novak & Gowin, 1988) se puede afirmar que los mapas conceptuales de los alumnos deberían reflejar la apropiación de los conceptos que se plantean en los textos, lo cual implicaría que en ninguna o en contadas ocasiones, los mapas conceptuales muestren fragmentos literales del material estudiado. Sin embargo, lo que ocurre en la mayoría de los casos es precisamente lo contrario, a estas coincidencias entre las Unidades de significado y los Párrafos, se las ha llamado Unidad de significado textual (UST). Esto sugiere que el alumno no ha sido capaz de apropiarse del significado del texto y posteriormente representarlo en un mapa conceptual, por lo que en realidad lo que hace es apropiarse de la estructura lineal del texto para cumplir con un mapa conceptual. Los análisis mostrados aquí con las UST aplican para los cuatro textos.

Véase la figura 1, el Párrafo que sirvió de base a esta Unidad de significado es el primer párrafo del apartado correspondiente a este modelo del conocimiento. Esta manera de elaborar las Unidades de significado con base en las partes iniciales de un texto ya ha sido reportada anteriormente (Aguilar Tamayo et al., 2012), si bien ahí se encontró que los mapas conceptuales se elaboran a partir de las primeras tres o cuatro páginas, dada la profundidad y el detalle de esta investigación es que se propone hablar de párrafos.

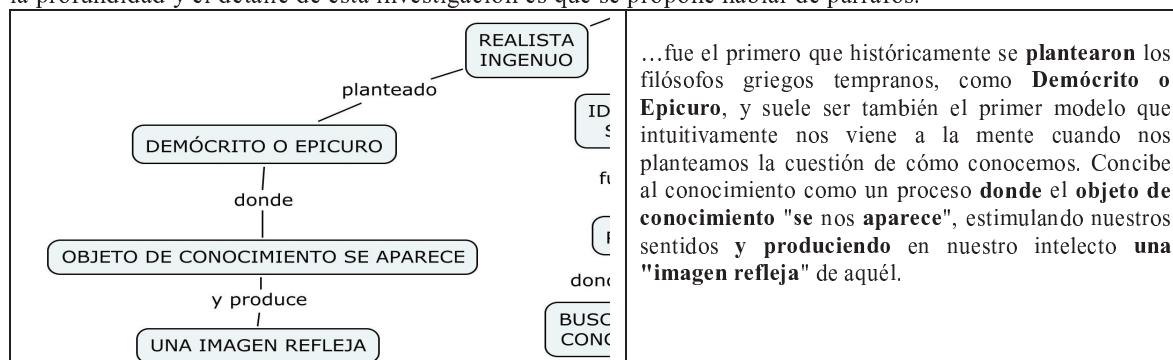


Figura 1. Ejemplo de Unidad de significado textual. Del lado izquierdo de la figura se observa la Unidad de significado textual (UST) coincidente con el Párrafo que se muestra a la derecha. Nótese cómo la UST se apropió de la estructura lineal de éste, es decir, los conceptos y enlaces son tomados literalmente del texto. Además son presentados en la misma secuencia, mientras que la Unidad de significado textual muestra (planteado + DEMÓCRITO O EPICURO + donde + OBJETO DE CONOCIMIENTO SE APARECE + y produce + UNA IMAGEN REFLEJA), el Párrafo muestra (plantearon + Demócrito o Epicuro + donde + objeto de conocimiento se + aparece + y produciendo + una imagen refleja).

En el siguiente párrafo del texto analizado, se habla de este modelo del conocimiento, realista ingenuo, en los términos que se plantearon en la parte correspondiente a los textos, esto es, desde el punto de vista del sujeto, del objeto y de la relación del conocimiento, algo que no aparece en el fragmento del mapa conceptual mostrado. Esto abre la pregunta ¿por qué el alumno no fue capaz de detectar en el texto y de representar en el mapa conceptual que la idea principal de este apartado radica ahí en ese párrafo y no en otro?

Possiblemente la respuesta se encuentre en que el criterio para elaborar la Unidad de significado, como puede ser la jerarquía, no obedece a una pregunta de enfoque o al dominio del conocimiento, sino a la narración, donde la jerarquía conceptual pasa así a un segundo plano para dar cabida a la narrativa textual. Parece entonces que al alumno le preocupa más, o ha adquirido la práctica de, plasmar la secuencia narrativa de los textos, que hacer un esfuerzo por analizar la lectura. Dadas las resistencias mostradas para la aceptación del mapa conceptual, también puede ser que el alumno utilice mecanismos de evasión o simulación.

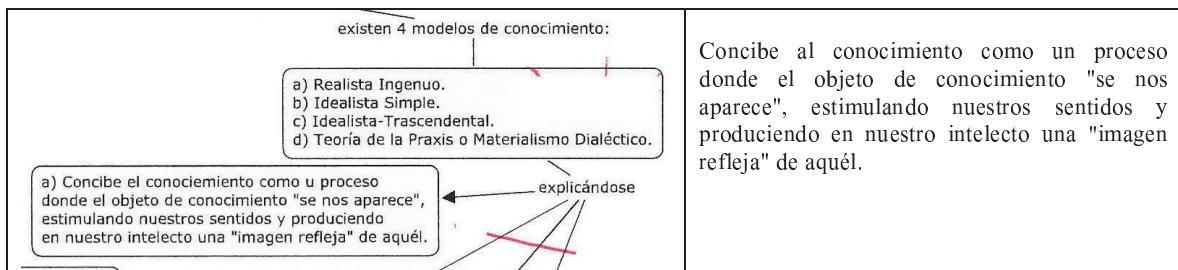


Figura 2. Ejemplo de Unidad de significado textual. Del lado izquierdo de la figura se observa la Unidad de significado (concepto inferior) coincidente con el Párrafo que se muestra a la derecha. En este caso la Unidad de significado transcribe completa la oración, no se ha hecho el esfuerzo por separar como conceptos independientes a los modelos del conocimiento (concepto superior). Lo mismo sucede con la explicación que se pretende del modelo Realista ingenuo; si acaso, el autor del mapa conceptual ha dejado una pista indicando, con el inciso “a”, que ese concepto-explicación corresponde al modelo señalado.

Obsérvese ahora la figura 2, se puede pensar que la deficiencia técnica de este fragmento del mapa conceptual obedece a que es la primera lectura, o que son los primeros mapas conceptuales elaborados, sin embargo, comparándolo con la figura 1, puede verse que no es un problema de adquisición de la técnica únicamente. Inclusive se puede observar que las frases entrecerrilladas del párrafo, que se muestran a la derecha de la figura, han sido copiadas fielmente, junto con el punto que pone fin a la frase. Este tipo de transcripciones literales de fragmentos textuales se detectaron en todos los textos analizados.

Para fines de comparación, véase la figura 3, esta Unidad de significado proviene de la lectura de Aguilar Villanueva (1998), considerada como la más compleja. A este tipo de Unidad de significado se le ha denominado de Síntesis, debido a que no existen coincidencias con ningún tipo de Párrafo en particular, es por eso que no se muestra ningún fragmento de texto en la parte derecha de la figura. En este caso el alumno construyó la Unidad de significado con base en la jerarquía conceptual, es decir, el alumno no se apropió de la estructura lineal del Párrafo, sino de los conceptos. En esta lectura Aguilar Villanueva propone que el objeto de conocimiento de la administración pública puede ser concebido como institución, como proceso o como razón técnica. En los mapas conceptuales analizados las Unidades de significado síntesis son escasas, se considera que puede deberse a que este tipo de unidades requieren de cierta capacidad de comprensión lectora por parte del alumno, del uso de estrategias de lecturas, y de la actitud de querer aprender significativamente para construir el mapa conceptual.



Figura 3. Unidad de significado síntesis. Este tipo de unidades se caracteriza porque no hay coincidencias con algún Párrafo o fragmento de párrafo en particular. Puede considerarse que en este caso hubo una apropiación de los conceptos en lugar de una apropiación de la estructura lineal del texto. La *Unidad de significado* se ha elaborado a partir de la jerarquía conceptual en lugar de la narración.

7 Conclusiones

La comprensión es un proceso que puede ser entendido en diferentes niveles. Un primer nivel cuyo objetivo final sería la representación de la estructura semántica de un texto, dicha representación es producto de poner en relación ciertas representaciones proposicionales con otras. Un segundo nivel implicaría la integración de la nueva información, en este caso proveniente de los textos, con los conocimientos previos. Un tercero supone un origen social al aprendiz y al conocimiento. Es evidente que los fragmentos de los mapas conceptuales mostrados en las figuras 1 y 2 son una muestra de que los alumnos que los realizaron pueden ser ubicados dentro del primer nivel.

Partiendo de las características del texto que se analiza en este artículo, se considera que una de las razones por las cuales los mapas conceptuales resultan deficientes tiene que ver con los distintos niveles de habilidades lectoras. Se infiere que dichas habilidades fueron un factor importante para que los alumnos no pudieran realizar al menos dos tareas, la primera de ellas sería la identificación de la idea principal del texto y su relación con las ideas secundarias. Una vez hecho lo anterior, la siguiente tarea consistiría en representar lo comprendido en un mapa conceptual. Recordando lo comentado sobre la figura 2, se puede afirmar que la deficiente habilidad como lector de su realizador, le impidió identificar los 4 modelos del conocimiento para representarlos posteriormente de manera separada en el mapa conceptual. Tampoco pudo identificar que la idea principal sobre ese modelo del conocimiento se encontraba en el segundo párrafo de ese apartado.

Como se mencionó fueron escasos los alumnos que presentaron versiones posteriores de su mapa conceptual, el proceso de reelaboración es importante porque permite al alumno darse cuenta de sus errores en lo técnico y en los contenidos. Le ayuda a replantearse nuevas preguntas con la consiguiente modificación de su mapa conceptual, también puede hacer evidente su relación con el conocimiento en términos de lo que conoce y lo que desconoce y, de integrar la nueva información a sus conocimientos previos. Dadas la prácticas de enseñanza y aprendizaje arraigadas en la memorización y la *recompensa*, resulta poco atractivo para los estudiantes pensar en la reelaboración del mapa conceptual. Si bien no fue objeto de estudio en este trabajo, es importante señalar la ayuda que brindan los apoyos mediacionales en la elaboración de los mapas conceptuales (Acuña, Aguilar Tamayo, y Manzano C., 2012).

Por último, todos estos elementos muestran la creciente necesidad de reflexionar críticamente sobre una didáctica del mapa conceptual dadas las dificultades que existen por parte de los estudiantes para apropiarse de esta herramienta para facilitar su comprensión y aprendizaje.

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ESTUDO SOBRE A NATUREZA ESTÁTICA OU DINÂMICA DAS PROPOSIÇÕES EM MAPAS CONCEITUAIS SOBRE BIOÉTICA

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Abstract. Os mapas conceituais (MCs) são formados por proposições que podem ser avaliadas quanto a sua natureza estática (descritiva) ou dinâmica (expressa interdependência entre os conceitos). O objetivo desse trabalho foi verificar como a natureza das proposições se altera em duas condições experimentais: sem estímulos para proposições dinâmicas (C1) e com estímulos para proposições dinâmicas (C2). Os resultados revelaram que mais de 70% dos MCs apresentaram mudanças discretas (ou nenhuma) e que menos de 30% dos MCs mudaram a natureza das proposições. Além disso, os MCs que ficaram mais dinâmicos representam cerca de 15% do total (n=54). Dois fatores podem explicar esse fato: (1) o MC elaborado com as demandas descritas para C1, com natureza estática, foi consultado pelos alunos durante a condição C2 e, (2) os MCs com natureza estática não respondem à pergunta focal iniciada com “como”, que requer proposições dinâmicas que explicitem relações de interdependência.

Keywords: Mapas conceituais, Proposições dinâmicas, Análise proposicional, Pergunta focal, Avaliação.

1 Proposições estáticas e dinâmicas nos mapas conceituais

As proposições são os elementos que tornam os mapas conceituais (MCs) diagramas capazes de comunicar semanticamente as relações entre conceitos e eventos (Novak, 2010). Isso explica boa parte da diferença que existe entre os vários tipos de mapas que são frequentemente classificados como organizadores gráficos (Davies, 2011). A estrutura proposicional contendo “conceito inicial – termo de ligação → conceito final” é uma forma poderosa de externalizar e compartilhar significados com outras pessoas, justificando o crescente interesse no uso do mapeamento conceitual para processos que envolvam a aprendizagem e a colaboração (Cañas & Novak, 2006; Correia, 2012). Atualmente, o uso dos MCs extrapola o âmbito educacional e já atinge organizações como empresas e corporações, visto que aprender e colaborar são atividades valorizadas no âmbito da sociedade do conhecimento (Novak & Cañas, 2010; Moon et al., 2011).

Além da clareza semântica, as proposições podem ser analisadas de acordo com o conteúdo da mensagem que elas carregam (Cañas & Novak, 2006). Em outras palavras, é possível avaliar se as relações conceituais são meramente descritivas (pensamento estático), ou se há alguma relação de interdependência funcional (ex. causa e efeito) entre os conceitos da proposição (pensamento dinâmico). A diferença entre descrever a relação entre conceitos e estabelecer uma relação de causa e efeito é um indicador de entendimento conceitual e, por isso, há vários pesquisadores interessados em estudar mais detalhadamente a natureza das proposições que os alunos declaram nos MCs (Derbentseva et al., 2006, 2007; Miller & Cañas, 2008a, 2008b; Safayeni et al., 2005; Romano Jr. & Correia, 2010). A literatura atual apresenta 3 pontos que merecem ser destacados:

- Os MCs podem apresentar proposições estáticas (descrevem relações entre conceitos) e dinâmicas (mostram relações de interdependência funcional entre conceitos).
- Os MCs favorecem as proposições estáticas, resultando em conteúdo conceitual meramente descritivo.
- O aumento da quantidade das proposições dinâmicas nos MCs depende de indução provocada no momento da demanda de elaboração do MC. Essa demanda deve considerar o uso de estrutura cíclica, a quantificação do conceito inicial e a pergunta focal iniciada com “como”.

Inspirado pelos trabalhos da literatura, nosso grupo de pesquisa desenvolveu uma taxonomia para analisar e classificar as proposições dos MCs (Romano Jr. & Correia, 2010). A análise proposicional (AP) considera o esquema taxonômico apresentado na Figura 1 para classificar as proposições de acordo com a natureza do seu conteúdo (estático/dinâmico), não levando em consideração a correção conceitual do conteúdo declarado (essa é outra análise que merece ser feita e é complementar a proposta desse trabalho). Por meio da AP é possível classificar as proposições em estáticas, que possuem um caráter descritivo, e proposições dinâmicas, que consideram a relação de ação, influência, dependência, proporcionalidade ou causa e efeito entre conceitos.

A categoria primária da taxonomia distingue as proposições em estáticas (E) e dinâmicas (D). A categoria secundária refina a classificação das proposições dinâmicas, considerando a existência (ou não) de relações de causa e efeito: definimos as proposições dinâmicas não causais (D0) e as proposições dinâmicas causais (D1). A categoria terciária considera a presença de quantificação (ou não) dos conceitos da proposição. No caso das

proposições dinâmicas não causais (D0) é possível ter ambos conceitos sem quantificação (D00) e somente um dos conceitos com quantificação (D01). Já no caso das proposições dinâmicas causais (D1) é possível ter ambos conceitos sem quantificação (D10), somente um dos conceitos com quantificação (D11) e ambos os conceitos com quantificação (D12).

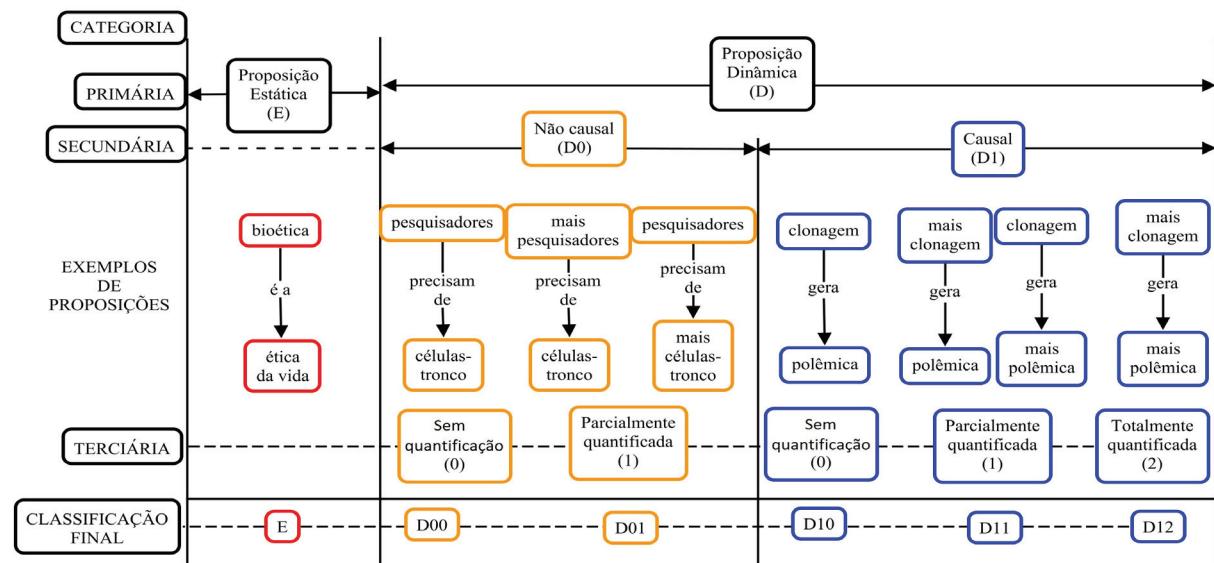


Figura 1. Esquema taxonômico para classificação de proposições. Categorias primárias: estática (E) e dinâmica (D); categorias secundárias: não causal (D0), e causal (D1); categorias terciárias: conceitos sem quantificação (0), somente um conceito quantificado (1) e ambos conceitos quantificados (2).

O objetivo desse trabalho foi verificar como a natureza das proposições pode ser alterada quando os alunos elaboraram os MCs em duas condições distintas: condição 1 (C1) sem estímulos para proposições dinâmicas e condição 2 (C2) com estímulos para proposições dinâmicas. A hipótese de trabalho, que se sustenta na literatura já existente sobre o tema, indica que haverá mais proposições dinâmicas nos MCs elaborados em C2.

2 Procedimentos de pesquisa

2.1 Coleta dos dados

Os MCs (n=54) foram coletados durante a disciplina de ACH0011 Ciências da Natureza (CN), oferecida pela Escola de Artes, Ciências e Humanidades (EACH/USP Leste). As discussões sobre o tema bioética envolveram quatro conteúdos: (i) a evolução e a origem da vida, (ii) o DNA e os avanços da biologia molecular, (iii) as implicações médicas da biologia molecular e (iv) a lei brasileira de biossegurança. Os alunos passaram por um período de treinamento em MCs nas aulas iniciais da disciplina, conforme descrição publicada na literatura (Aguiar et al., 2014; Aguiar & Correia, 2013; Correia et al., 2008). Maiores detalhes sobre a disciplina CN podem ser obtidos em Correia et al. (2010).

Os MCs foram elaborados sob duas condições diferentes. As demandas feitas pelo professor da disciplina não estimularam as proposições dinâmicas num primeiro momento (condição 1, C1) e estimularam as proposições dinâmicas num segundo momento (condição 2, C2). O principal objetivo da C1 era permitir que os alunos se preparassem para elaborar o MC sob a C2, que era um dos momentos de avaliação formal da disciplina CN. A Tabela 1 compara as diferenças entre C1 e C2, reiterando que elas foram planejadas visando a obtenção de uma maior incidência de proposições dinâmicas em C2.

As instruções específicas para a elaboração dos MCs nas C1 e C2 são apresentadas na Figura 2. Algumas características da demanda apresentada na C2 (Figura 2b) foram especialmente planejadas para favorecer a formulação de proposições dinâmicas e seguem as recomendações descritas na literatura para estimular o pensamento dinâmico (Cañas & Novak, 2006; Safayeni et al., 2005; Derbentseva et al., 2006, 2007):

- Há um conceito pré-selecionado pelo professor (clonagem) e que é de uso obrigatório.

- A pergunta focal pré-definida pelo professor (*Como a bioética regula a relação entre a ciência e a sociedade?*) começa com “como”. Isso remete a uma explicação de processo e evita a descrição de eventos ou objetos.
- A disposição espacial dos conceitos na folha é pré-definida: o número de conceitos é restrito (n=9), mas não há restrições quanto ao número de proposições. Essa estrutura é denominada semiestruturada (Figura 2b) e ela foi inspirada nos MCs cílicos (restringem a quantidade de conceitos e proposições).

Tabela 1: Características das demandas (condição C1 e C2) feitas pelo professor para os alunos produzirem seus MCs.

Parâmetro	Condição C1 Preparação/estudo para a prova	Condição C2 Prova da disciplina CN
Material de consulta	Consulta livre a textos/vídeos utilizados em aula.	Consulta livre ao MC elaborado na condição C1.
Quantidade de conceitos	24 conceitos escolhidos pelo aluno, a partir dos textos/vídeos utilizados em aula.	9 conceitos, sendo que 1 deles é obrigatório e indicado pelo professor.
Pergunta focal	Definida livremente pelo aluno, após a elaboração do MC.	Pré-definida pelo professor. Inicia-se com “como” para estimular a formulação de proposições dinâmicas.
Estrutura da rede proposicional	Restrição quanto a quantidade de conceitos. Não há restrição quanto a disposição espacial dos conceitos.	Restrição quanto a quantidade de conceitos e disposição espacial dos conceitos.
Tempo para elaboração	Há 1 semana entre a solicitação e a data da entrega. Não há restrição de tempo.	O tempo de elaboração é controlado e restrito a 60 minutos.

2.2 Análise dos dados

2.2.1 Análise da natureza das proposições

A análise da natureza das proposições (AP) requer a organização de todo o conteúdo proposicional dos MCs em uma tabela, onde cada linha contém uma proposição organizada em três colunas (conceito inicial – termo de ligação → conceito final). Cada linha dessa tabela foi lida por dois avaliadores diferentes e o procedimento para definir a classificação das proposições está descrito na sequência de perguntas apresentada na Tabela 2.

Tabela 2: Procedimento para classificar as proposições de acordo com a sua natureza estática (E) ou dinâmica (D), utilizando como referência o esquema taxonômico apresentado na Figura 1.

Foco da análise	Categoria	Questões para categorização?	Respostas	Ação	Classificação final
Termo de ligação	Primária	1) Os termos de ligação tem verbos?	Sim	Ver Questão 2.	-
			Não	Proposição estática.	E
	Secundária	2) O verbo é transitivo?	Não	Proposição estática.	E
			Sim	Proposição dinâmica. Ver Questão 3.	D
Proposição	Secundária	3) A relação conceitual expressa uma relação de causa e consequência?	Não	Proposição dinâmica não causal. Ver Questão 4.	D0
			Sim	Proposição dinâmica causal. Ver Questão 4.	D1
	Terciária		Nenhum	Proposição dinâmica (...) não quantificada	D00, D10
		4) Quantos conceitos estão quantificados (ex. aumento do controle)?	1	Proposição dinâmica (...) parcialmente quantificada	D01, D11
			2	Proposição dinâmica (...) totalmente quantificada	D12

Os resultados foram consolidados numa matriz X (57x6), onde cada linha contém os dados referentes a um MC e cada coluna apresenta as informações sobre uma das variáveis da AP (E, D00, D01, D10, D11 e D12). O teste-*t* de Student foi utilizado para comparar as médias das variáveis da AP e verificar se existem diferenças estatisticamente significativas entre os MCs obtidos nas C1 e C2. O programa SPSS (v. 22.0, IBM, EUA) foi utilizado para realizar os cálculos estatísticos.

(a)

[P3-CN2012] Preparação do MAPA CONCEITUAL a ser utilizado como COLA OFICIAL

Considere os materiais utilizados durante as discussões nas aulas 11, 12, 13 e 14. Faça uma (re)leitura dos textos, (re)veja os vídeos indicados, refita sobre as nossas discussões e selecione os conceitos mais relevantes de cada aula (máximo 4 conceitos por material/instrucional). Registre os seus conceitos no quadro a seguir. Você pode relacionar, no máximo, 24 conceitos diferentes.

[A] Aula 11 (Explicando o muito improvável) Texto do Richard Dawkins
Indique a cor das caixinhas dos conceitos A1-A4
Cor: _____

A1)	
A2)	
A3)	
A4)	

[B] Aula 12 (Ciência, genética e ética: memorando para Tony Blair) Texto do Richard Dawkins
Indique a cor das caixinhas dos conceitos B1-B4
Cor: _____

B1)	
B2)	
B3)	
B4)	

[D] Aula 13 (Documentário "DNA: a promessa e o preço")
Indique a cor das caixinhas dos conceitos D1-D4
Cor: _____

D1)	
D2)	
D3)	
D4)	

**[E] Aula 14 (Vídeo "Apimorar é humano") TED
Gregory Stock**
Indique a cor das caixinhas dos conceitos C1-C4
Cor: _____

C1)	
C2)	
C3)	
C4)	

[D] Aula 13 (Documentário "DNA: a promessa e o preço")
Mesma cor das caixinhas D1-D4
Cor: _____

D5)	
D6)	
D7)	
D8)	

(b)

PERGUNTA FOCAL & INSTRUÇÕES

Como a bioética regula a relação entre a ciência e a sociedade?

[1] O retângulo pontilhado indica o conceito inicial do MC. [2] "CLONAGEM" é o conceito obrigatório a utilizado (destaque-o no seu MC). [3] Numere as proposições, indicando a ordem de leitura. [4] Indique a fonte do conceito no círculo que está vinculado a cada retângulo, de acordo com a codificação utilizada para elaborar a coluna oficial da P3.

[A] "Explicando o muito improvável" (txt, R. Dawkins)
[B] "Aprimorar é humano" (vídeo, G. Stock)
[C] "Clonagem e células-tronco" (txt, M. Zatz)
**[D] "Ciência, genética e ética..." (txt, R. Dawkins)
[E] "DNA: a promessa e o preço" (vídeo, BBC)**

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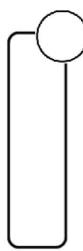
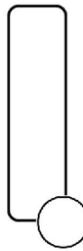


Figura 2. Instruções para os alunos produzirem o MC nas condições (a) C1 (preparação/estudo para a prova) e (b) C2 (prova).

A análise hierárquica de agrupamentos (HCA) foi utilizada para verificar se há padrões de similaridade entre todos os MCs ($n=54$) considerados nesse estudo. Os valores da matriz X foram divididos pela quantidade total de proposições de cada MC, visando minimizar o impacto da diferença de tamanho dos MCs produzidos nas condições C1 (24 conceitos) e C2 (9 conceitos). Essa exploração multivariada complementa as informações reveladas por meio dos métodos descritivos univariados (Correia & Ferreira, 2007). O programa Pirouette 3.11 (Infometrix, EUA) foi utilizado para realizar a HCA utilizando distância Euclidiana e método de Ward.

2.2.2 Análise de pertinência do conteúdo

Três pesquisadores fizeram a leitura de cada MC obtido sob C2 (Prova da disciplina CN) para avaliar a adequação das relações conceituais declaradas pelos alunos e a pertinência do conteúdo frente à pergunta focal, que foi pré-definida pelo professor. Após atingir o consenso, negociado durante duas reuniões, os MCs ($n=27$) foram classificados em 2 grupos: respondem à pergunta focal e não respondem à pergunta focal.

3 Resultados e discussões

3.1 Teste-t de Student

Os valores médios para os parâmetros da AP estão apresentados na Tabela 3. A comparação entre os MCs elaborados nas condições C1 e C2 indica que há diferença estatisticamente significativa nas médias de proposições E (estáticas) e D00 (dinâmicas não causais, sem quantificação). As médias de proposições D10 (dinâmicas causais, sem quantificação) não apresentam diferenças estatisticamente significativas. Proposições com conceitos quantificados ou parcialmente quantificados não foram encontradas (D11, D12) ou foram encontradas somente em um único MC (D01).

Tabela 3: Comparação das médias obtidas para as categorias da AP considerando os MCs obtidos nas condições C1 e C2.

	C1: Preparação/estudo para a prova M (DP)	C2: Prova da disciplina CN M (DP)	t
E	9,0 (4,2)	4,0 (1,8)	5,68*
D00	12,4(5,0)	6,0(2,3)	6,04*
D01	0,1 (0,2)	-	-
D10	1,8 (1,9)	1,4 (1,3)	0,90
D11	-	-	-
D12	-	-	-
ΣD	14,3 (5,3)	7,4 (2,6)	6,09*
Total de proposições	23 (5)	11 (2)	11,6*

*Os valores diferem para $p<0,0001$.

A maior quantidade de proposições E e D00 na condição C1 está relacionada ao tamanho desses MCs (24 conceitos), maiores do que os MCs elaborados na condição C2 (9 conceitos). A média de proposições dos MCs elaborados em C1 (23 ± 5) acompanhou essa tendência e é cerca de 2 vezes maior do que a média de proposições dos MCs elaborados em C2 (11 ± 2). Esses valores mostram que a variação do tamanho do MC (quantidade máxima de conceitos permitida em C1 e C2) teve impacto direto no número e no tipo (E e D00) de proposições elaboradas pelos alunos.

A quantidade de proposições D10 é similar em C1 ($1,8 \pm 1,9$) e C2 ($1,4 \pm 1,3$). Esse fato pode ser explicado pela complexidade que existe ao se estabelecer proposições D10 (dinâmicas causais): os alunos precisam, nesse caso, ter domínio dos conceitos envolvidos, perceber a relação de causa e efeito e encontrar uma formulação proposicional clara capaz de comunicar tal relação. A sequência de proposições a seguir foi extraída de um MC elaborado por aluno na condição C1 para ilustrar o aumento da complexidade conceitual que existe quando compararmos as proposições E, D00 e D10.

- E: Células-tronco – são usadas para → clonagem terapêutica [P4-5/E] na Figura 5a. Proposição com foco descritivo, apontando possível uso para as células-tronco.
- D00: Avanços tecnológicos – precisam de → investimentos financeiros [P11/D00] na Figura 5a. Proposição revela interdependência funcional entre os conceitos (o primeiro depende do segundo).
- D10: Avanços tecnológicos – proporcionaram a → revolução genética [P12/D10] na Figura 5a. Proposição revela interdependência funcional entre os conceitos, que se expressa por meio de relação de causa e efeito (o primeiro é a causa e o segundo é o efeito).

O alto grau de domínio conceitual exigido para a elaboração de proposições D10 explica também porque elas aparecem em menor quantidade (menos de 2 proposições D10 por MC em C1 e C2). É importante destacar que as proposições dinâmicas D00 foram as mais utilizadas pelos alunos em ambas as condições (C1 e C2) e que, na somatória, as proposições dinâmicas (D00+D10) estão mais presentes do que as proposições estáticas (E) na condição C1 ($E = 9,0 \pm 4,2$; $\Sigma D = 14,3 \pm 5,3$; $t = 4,17$) e C2 ($E = 4,0 \pm 1,8$; $\Sigma D = 7,4 \pm 2,6$; $t = 5,59$).

A ausência de proposições com conceitos quantificados (D01, D11 e D12) pode ser explicada pelo fato do conceito obrigatório (“clonagem”) não apresentar quantificação (ex. “aumento da clonagem”).

3.2 Avaliação da similaridade dos MCs

A análise realizada na seção anterior considera somente os valores médios e uma apreciação do conjunto dos MCs obtidos em C1 e C2. A análise hierárquica de agrupamentos (HCA) tem como objetivo avaliar individualmente todos os MCs ($n=54$) desse estudo, para verificar se há similaridade entre eles. O dendrograma apresentado na Figura 3 mostra 3 agrupamentos com 63% (0,63) de similaridade. Os valores médios para as variáveis E, D00 e D10 que descrevem os MCs dos grupos I, II e III são apresentados na Tabela 4.

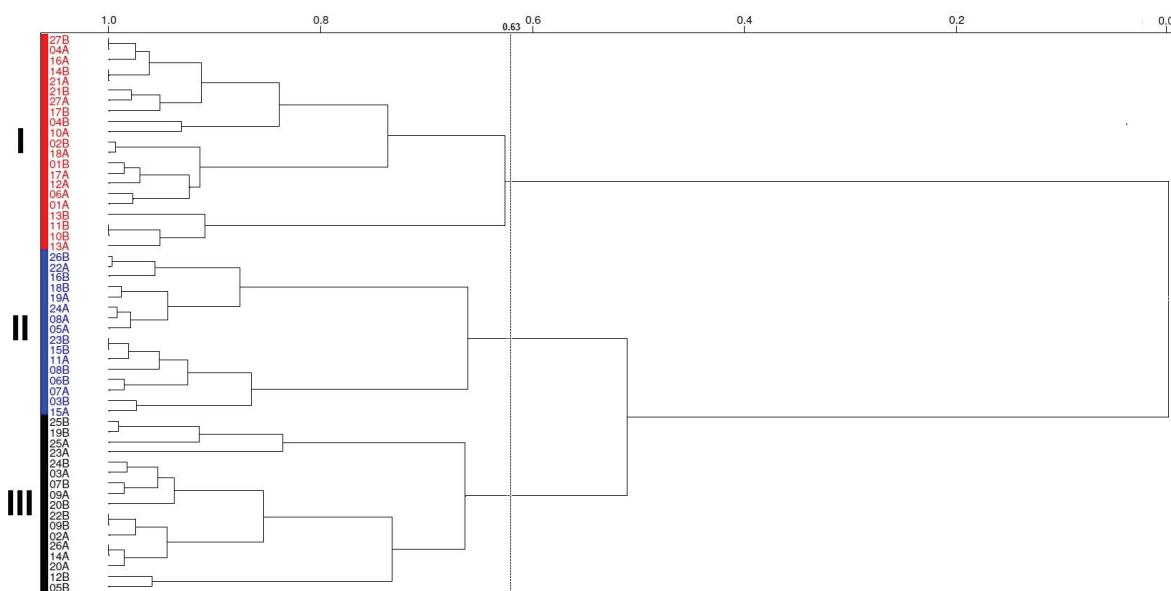


Figura 3. Dendrograma obtido a partir da HCA para a matriz de dados X (54x3), considerando somente os valores para E, D00 e D10. A linha vertical tracejada indica os grupos (I-III) que foram identificados com 63% (0,63) de similaridade.

Tabela 4: Caracterização dos grupos I-III obtidos por HCA a partir dos valores médios para as variáveis E, D00 e D10, a quantidade de MCs elaborados em C1/C2 e o total de MCs em cada agrupamento.

	Grupo I	Grupo II	Grupo III	Total
E	$0,24 \pm 0,10$	$0,40 \pm 0,09$	$0,52 \pm 0,11$	1 (100%)
D00	$0,69 \pm 0,07$	$0,51 \pm 0,05$	$0,34 \pm 0,07$	1 (100%)
D10	$0,07 \pm 0,09$	$0,09 \pm 0,09$	$0,14 \pm 0,10$	1 (100%)
ΣD	$0,76 \pm 0,11$	$0,60 \pm 0,10$	$0,48 \pm 0,12$	-
MCs elaborados em C1	11	8	8	27
MCs elaborados em C2	10	8	9	27
Total de MCs	21 (39%)	16 (30%)	17 (31%)	54 (100%)

A composição dos grupos I-III considerando a quantidade total e o tipo de MCs (C1/C2) é parecida. Porém, os MCs do grupo I destacam-se por ter maior proporção de proposições dinâmicas (76% vs 24% estáticas), enquanto os MCs do grupo III tem distribuição mais equilibrada de proposições dinâmicas e estáticas (52% vs 48%). Os MCs do grupo II ficam em situação intermediária (60% vs 40%), permitindo estabelecer uma ordem descendente do caráter “dinâmico” da rede proposicional dos MCs considerados nesse estudo: grupo I > grupo II > grupo III. A distribuição de MCs elaborados nas condições C1 e C2 foi praticamente a mesma em todos os grupos, indicando que as demandas apresentadas estimularam a produção de proposições dinâmicas de maneira similar. Em outras palavras, a condição C2 (Prova da disciplina CN) não estimulou a elaboração de proposições dinâmicas em maior quantidade, quando comparada à condição C1 (Preparação/estudo para a prova). Isso refuta a hipótese de trabalho e exige uma investigação mais detalhada de como os MCs de cada um dos alunos se localiza nos grupos I- III obtidos por HCA.

Há um grupo de 12 alunos (44%) cujos MCs elaborados em C1 e C2 se localizam num mesmo agrupamento. Nesses casos, a natureza da rede proposicional permaneceu inalterada, independente da forma pela qual a elaboração do MC foi solicitada. Esses 12 alunos se distribuíram da seguinte forma:

- 7 alunos tem seus MCs classificados no grupo I (76% dinâmicas vs 24% estáticas).
- 2 alunos tem seus MCs classificados no grupo II (60% dinâmicas vs 40% estáticas).
- 3 alunos tem seus MCs classificados no grupo III (52% dinâmicas vs 48% estáticas).

Há outro grupo de 15 alunos (56%) cujos MCs elaborados em C1 e C2 se localizam em diferentes agrupamentos. Isso significa que as demandas de elaboração dos MCs podem ter exercido influência sobre a natureza das proposições construídas pelos alunos. Esses 15 alunos podem ser agrupados em 2 casos gerais:

- 9 alunos tem seus MCs/C1 classificados no grupo I e seus MCs/C2 classificados nos grupos II ou III, indicando redução do caráter dinâmico da rede proposicional na prova de CN.
- 6 alunos tem seus MCs/C1 classificados no grupo II ou III e seus MCs/C2 classificados nos grupos I ou II, indicando aumento do caráter dinâmico da rede proposicional na prova de CN.

3.3 Resposta à pergunta focal

A Figura 4 apresenta a classificação dos MCs em função da análise do seu conteúdo, considerando a pergunta focal que foi formulada (*Como a bioética regula a relação entre a ciência e a sociedade?*). Esse resultado permitem estabelecer uma relação entre os grupos I-III obtidos a partir da HCA e a aderência ou não aderência à pergunta focal.

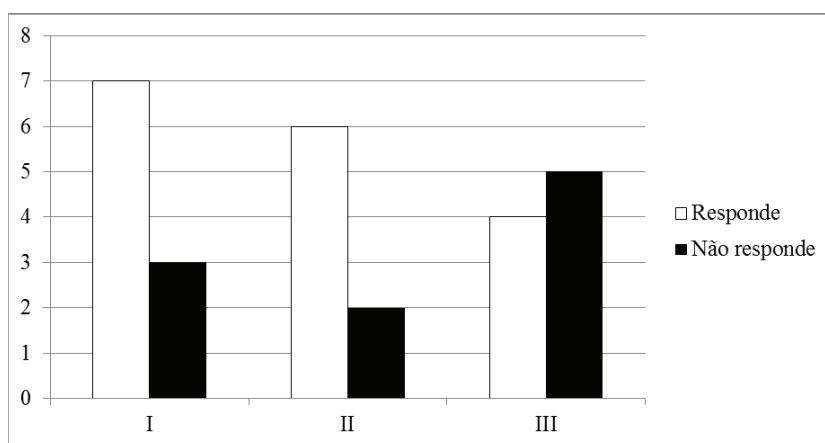


Figura 4. Análise dos MCs elaborados sob C2 quanto à aderência à pergunta focal. Nota-se que há maior incidência de MCs que respondem à pergunta focal nos grupos I e II, que possuem MCs com predomínio de proposições dinâmicas.

Os MCs presentes nos grupos I e II apresentam maior proporção de proposições dinâmicas (76% e 60%, respectivamente). Esses MCs, em sua maioria, respondem a pergunta focal ($n = 13$, sendo 6 MCs do grupo I e 7 MCs do grupo II) e somente uma pequena parcela ($n = 3$, sendo 2 MCs do grupo I e 2 MCs do grupo II) não respondem à pergunta focal. Esses dados demonstram que os MCs que apresentam maior número de proposições dinâmicas, tendem a responder a pergunta focal iniciada com “como”.

Os MCs presentes no grupo III apresentam um equilíbrio no número de proposições dinâmicas (48%) e estáticas (52%). A comparação com o número de MCs que respondem a pergunta focal ($n = 4$) e não respondem a pergunta focal ($n = 5$) sugere que a fuga em responder a pergunta focal é maior quando os MCs contém maior proporção de proposições estáticas.

A Figura 5 ilustra os MCs que um aluno elaborou nas condições C1 (Figura 5a) e C2 (Figura 5b). Nesse caso, houve mudança da natureza da rede proposicional e o MC/C2 (Prova de CN) ficou com caráter mais dinâmico do que o MC/C1 (Preparação/estudo para a prova). As características gerais dos MCs são apresentadas comparativamente na Tabela 5.

(a)

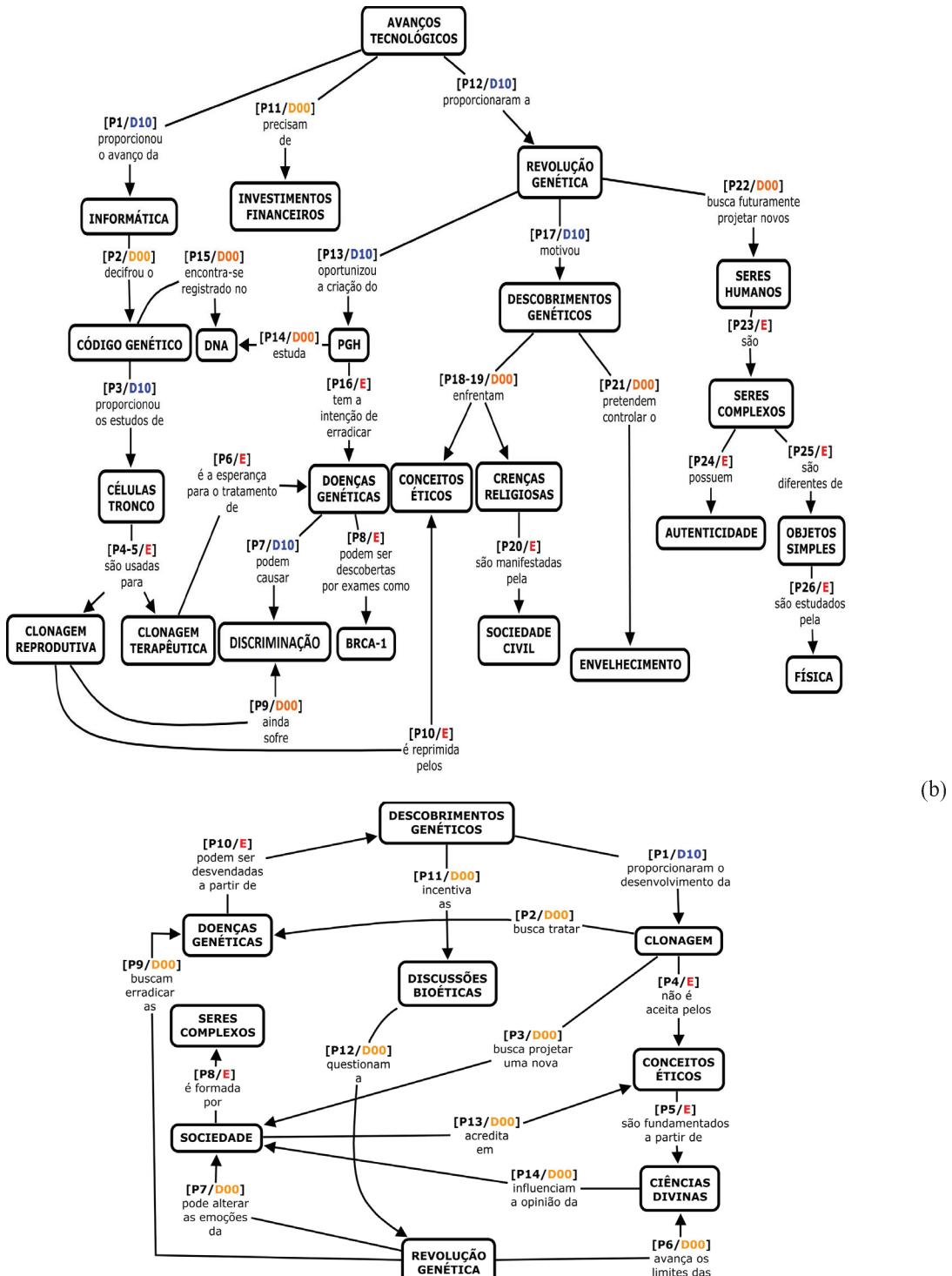


Figura 5. MCs elaborados por um dos alunos da disciplina CN nas condições (a) C1 e (b) C2.

Tabela 5: Comparação das características das proposições dos MCs elaborados por um aluno nas condições C1 e C2.

	MC elaborado em C1 (Figura 5a) Preparação/estudo para a prova	MC elaborado em C2 (Figura 5b) Prova da disciplina CN
Grupo	II	I
E (%)	42	29
D00 (%)	35	64
D10 (%)	23	7
ΣD (%)	58	71

4 Conclusões

A análise conjunta dos dados referentes aos MCs dos alunos não permitiu identificar um efeito claro da demanda de elaboração de MCs sobre a natureza das proposições enunciadas pelos alunos. Houve casos em que os MC/C1 e MC/C2 são similares em termos de proposições estáticas e dinâmicas; há situações em que houve mudanças aumentando e reduzindo o caráter “dinâmico” da rede proposicional. Aparentemente, há outros fatores que precisam ser considerados para melhor compreender a relação entre o formato da demanda de elaboração de MCs e a natureza das proposições. Os conhecimentos prévios dos alunos e o intervalo entre a produção dos MCs devem ser parâmetros considerados em estudos futuros.

5 Agradecimentos

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EYE MOVEMENT PATTERNS OF CONCEPT MAP NOVICES: AN EXPLORATORY STUDY ON CHINESE TERTIARY STUDENTS

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Abstract: In recent years, the use of eye-tracking technologies has drawn increasing attention of educational researchers. However, there is still little research on the information processing patterns and consequences when learners reading concept maps based on eye movement data. This study is our initial attempt towards such direction. In this study we explored the eye movement patterns of concept map novices. Good concept maps are generally drawn with specified guidelines and students are always suggested to read the concept maps according to these guidelines. However, most of Chinese students have no experience of concept maps. Therefore, we are interested in their eye movement patterns when reading concept maps. Two layouts of concept maps (i.e., top-down layout and radial layout) were focused in the study. Eye movement data were captured by an unobtrusive eye-tracking device. 28 undergraduate students majored in economics and management in a famous Chinese university participated in the experiment. Results show that the top-down left-right pattern (i.e., text-transfer model) is dominated for Chinese tertiary students, no matter the layout of a concept map. Results also indicate that the visual attention of nodes and linking phrases are not evenly distributed, and the center and upper-left region of a concept map receives more fixations.

Keywords: Conceptual Maps, Eye tracking, information processing

1 Introduction

Educational researchers recently show increasing attention of the eye-tracking method, which has been intensively used in psychology and cognitive study. Compared to traditional interview and survey procedure, the eye-tracking method represents a promising way for tracking the cognitive process of learning (Adesope & Nesbit, 2013; Lai et al., 2013; Liu, 2014). Concept maps as graphical tools for organizing and representing knowledge have been proposed for more than 30 years. Guidelines to construct and read concept maps have been carefully designed. However there is little research on the real eye movement patterns when learner reading concept maps and we are not clear whether the eye movement patterns of concept map novices follow these guidelines. This study is an initial attempt to tackle the problem using an unobtrusive eye-tracking device in the context of Chinese tertiary students. Two typical concept map layouts (i.e., top-down hierarchical layout and radial layout) are focused in the study.

Prior studies have demonstrated the close link between eye movement patterns and human cognitive processes (e.g., Rayner, 1998). Thus, study on eye movement patterns on different layout of concept maps will help to understand the cognitive process of learning using concept maps, to differentiate the impacts of visual layouts on concept map comprehension, and to provide instructional suggestions for concept map design and teaching.

The remainder of the study is as follows: Section 2 provides the theoretical framework of the paper, Section 3 describes the research method used in the study, Section 4 discusses the results and Section 5 concludes the paper with future work.

2 Theoretical Framework

The theoretical framework of eye movement patterns of concept map novices roots in theories about eye movement and concept map.

2.1 Eye movement and the eye tracking method

According to eye-mind assumption (Just & Carpenter, 1980), eye gaze and attention have close relationship during the process of visual information presentation. People often use their eyes to explore external environments, and focus their eyes on an area of interest. Eye movement represents attentional shifts, which have been widely studied in the fields of usability and product design, assistive technology, and training

simulations. Prior research has concluded that studying eye movements could help to understand pre-conscious mental operations, such as orienting, filtering, searching and semantic analysis. For example, study by Rayner (1998) reported that the patterns and measures of eye movement behaviors reflect the difficulty of information processing in the form of texts and images.

Visual perception falling within the normal range consists of three parts: foveal, parafoveal, and peripheral vision. Acuity is the greatest in the fovea, decreasing in the parafovea and periphery. In order to see things clearly, people frequently move their eyes to locate areas of interest in the region of fovea. Eye movement researchers have identified two general types of eye movement: fixations and saccades. Fixations refer to periods of 200 to 300 milliseconds in which eyes remain relatively still. Saccades are eye movements that occur between fixations. Studies have shown that different readers have different perceptual spans indicating areas of effective vision, and that new information is not acquired during saccades (Rayner, 1998).

The eye tracking method is basically developed based on the abovementioned characteristics of eye movements. It generally refers to a set of technologies which monitor and record the way a person looks at a particular text or image, and in what areas they fixed their attention, for how long and in what order. Such eye-tracking technology is used in educational research because it has potential to identify what information learners are attending to and the order of cognitive operations (Rayner, 1998; van Gog & Scheiter, 2010). Recently, Lai et al. (2013) reviewed 81 eye tracking papers in education and identified seven major research topics, i.e., effects of instructional strategies, patterns of information processing, individual differences, effects of learning strategies, reexamination of existing theories, social/cultural effects, and patterns of decision making.

Concept map as an effective knowledge representation medium can work as a visual stimulus to students. Thus, we believe that there is great potential in using the eye tracking method to analyze the eye movement patterns on and assess the impacts of concept maps. Recently, researchers have begun using eye movement data to build an understanding of how learners visually process concept maps. Nesbit, Larios, & Adesope (2007) found that participants gave early attention to nodes in the upper-left and central region of concept maps. Amadieu et al. (2009) used pupil dilation, fixation duration and navigational data to examine the effects concept map structure on disorientation, cognitive load, and learning from nonlinear documents. Bisra and Nesbit (2012) measured participants' eye movements while they were searching concept maps to gather information for argumentation. They found that participants' eyes fixated more on task-relevant nodes and more on nodes they later recalled correctly.

2.2 *Eye movement patterns*

Based on text reading patterns, prior research (Nesbit et al., 2007) suggests two possible eye-movement patterns: the text-transfer model and the hub-first model. Considering similar reading patterns of modern Chinese and western languages, we believe it is the truth for Chinese students.

The text-transfer model purports that learners tend to transfer text processing pattern to concept maps. Specifically, learners are likely to proceed concept maps from top to bottom, and from left to right. There would be an early saccade to the uppermost, leftmost node.

The hub-first model hypothesizes that concept map readers are seeking superordinate information. Hubs are nodes with a relatively large number of links to other nodes, which are likely to represent general information that is superordinate to information represented by other nodes. Hubs are generally centrally located in most concept maps. In a hub-first model, learners' earliest fixations are in the central region of the concept map, followed by nodes with a greater number of links.

2.3 *Characteristics of a good concept map*

Concept maps root in the Ausubel's assimilation theory. Decades of research and practice has demonstrated that concept maps can aid people of different ages to examine many fields of knowledge (Novak, 2010). They offer the flexibility of natural language and have the advantage of inducing their creators to organize their knowledge in a structured fashion, where concepts and their connections can be directly recognized.

Concept maps are composed of nodes that represent concepts and links that connect nodes to represent the relationships between concepts. Each node-link-node triplet forms a proposition with a meaningful statement about the object or event. These nodes and links are arranged in a hierarchical fashion with the most general concept at the top followed by more and more specific ones. The segments of a concept hierarchy represent different knowledge domains within the concept map. Links that cross segments, called cross-links, show how a

concept in one knowledge domain is related to another and represent creative leaps on the part of the knowledge modeler.

The definition delineates several key characteristics of a good concept map: 1) A concept map usually stems from one main idea; 2) The main idea branches into related general concepts; 3) General concepts can be subdivided into more specific concepts branching from them in several tiers; 4) Specific concepts are elaborated by example; 5) Concepts are usually nouns, representing objects or events and each concept should be a single idea and appear only once in the map; 6) Relationships between concepts are shown by linking phrases and all concepts should be linked; 7) Cross-links are used to connect concepts in two different paths of the map.

To meet these characteristics, Novak and colleagues purported a top-down hierarchical layout (Novak & Gowin, 1984), whereas other researchers construct these visual representations in a radial configuration (Jonassen, Reeves, Hong, Harvey, & Peters, 1997) with the root node exists in the center of the map and the next level concepts spread around the central root node.

The eye movement pattern should match the layout of concept map to achieve good cognitive performance. Intuitively, top-down layout requires text-transfer model of eye movement and radial layout requires hub-first model. Accordingly in this study we are interested in concept map novices' real eye movement patterns when processing the two layouts of concept maps.

3 Method

To explore concept map novices' eye movement patterns, we conducted a controlled laboratory experiment. The whole experiment, including a briefing session, a reading session, and a test session, took approximately 15 minutes to finish. 28 undergraduate students from economics and management major in a famous university in China volunteered for the experiment. The participants were asked to carefully read two concept maps adapted from current well-designed concept maps. In this paper, we focused on the reading session and reported the eye movement patterns emerged from the session.

3.1 Experiment settings

The experiment settings are shown in Figure 1. The experiment took place in a room containing a desktop computer, mouse, keyboard, camera, and eye-tracking device. A Tobii T120 eye-tracker was used to collect eye movement data with the support of Tobii Studio software. Tobii T120 tracked participant's eye movement by using an infrared light source to illuminate the pupils and then captured the reflection. Tobii T120 could provide highly accurate and precise gaze-position data in real-life conditions and robust eye tracking capability ensures very low data loss regardless of a participant's ethnic background, age, use of glasses, or contact lenses.

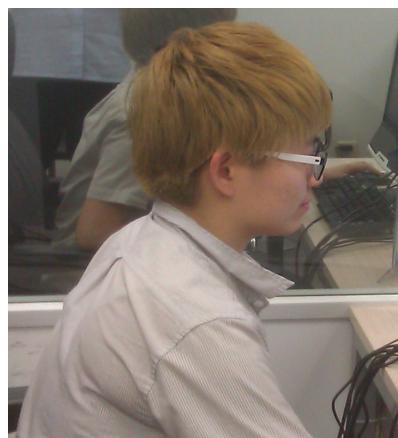


Figure 1. Experiment settings.

The eye-tracker was controlled by Tobii Studio software. This software offered a platform for recording eye movements, exporting raw eye gaze data, and multiple display visualizations such as video capture, gaze plot, and heat map. Along with gaze positions, mouse clicks and keystrokes were logged. Tobii Studio could also define areas of interest in order to filter the vast amounts of data into meaningful regions. In our settings, each node and linking phrase of a concept map was defined as an area of interest. Based on areas of interest, eye movement measures, such as fixation duration and fixation counts can be generated. The raw eye gaze data and eye movement measures can be exported to other commercial packages (e.g., IBM SPSS) for further analysis.

3.2 *Concept maps and procedure*

The two concept maps used in this study is adapted from the well-known Mars Exploration concept maps project. The focus question of one concept map is what capability advancements will result from a return to the moon, and another is what processes created asteroids. These topics are selected because the participants are generally not familiar with these topics while at the same time they are interested to know more about them. Due to the time constraints (less than 100 seconds) of one tasks in Tobii Studio, a few concepts in the original concept maps were deleted. Back-translation method was used to make sure the accuracy of translation from English to Chinese (Brislin, 1986). After translation, we redrew the two maps using CMapTools software. The top down layout and radial layout were prepared for the two concept maps respectively. Finally we got four concept maps as shown in Figure 2 ~ 5.

The experiment lasted for about 15 minutes and the time was determined by two rounds pilots study. The general procedure of the experiment was as followed: (1) a facilitator welcomed the participant, explained the facilities and tasks, and had him/her singed the consent form; (2) The participant conducted an eye-tracker calibration using the standard option in the Tobii Studio. The process took about 10 seconds by following moving red dots on the screen with eyes. (3) One top-down-layout concept map and one radial-layout concept map with different topics were randomly presented to the participants. Each map was shown for 100 seconds. The participants were asked to read and understand the two concept maps. (4) After reading the two concept maps, the participants were asked to complete a short quiz regarding to the content of concept maps and answer a questionnaire about experiences of reading concept maps with demographic information.

3.3 *Experiment control*

Prior studies have identified several sources of errors in concept mapping experiments, including variations in the participants' concept mapping proficiency, and variations in their prior domain knowledge. Accordingly, we have controlled these factors to minimize the influence of these sources of errors. Participants were carefully selected to make sure they have little knowledge about concept maps and domain knowledge about the two concept maps. Two items using 5-point Likert scale in the post-test questionnaire confirmed that these participants were general concept map novices ($\text{mean} = 1.21$, $\text{s.d.} = 0.45$) and they had limited knowledge of outer space ($\text{mean} = 1.67$, $\text{s.d.} = 0.81$).

4 Results with Discussions

As aforementioned, saccades and fixations are two general types of eye movement. Thus, to explore the novice's eye movement, in this paper we focused on the qualitative analysis of eye gaze plots and fixation heat maps generated during the concept map reading session of our experiment.

4.1 *Results of gaze plots*

A gaze plot displays movement sequence, order and duration of gaze fixations. Figure 2 exhibited a typical participant's eye gaze movement in the first 10 seconds on the top-down-layout concept map. In Figure 2, circles are labeled with fixation numbers before arrival and the diameters of the circles are positively related to fixation duration. The focus of the participant exists on the middle-left side of the concept map. We find that viewing begins with the top of the concept map, then moves on the second layer of the concept map. After that, the participant focuses its attention on the children nodes of the first node of the second layer, followed by the children nodes of the second node of the second layer. Such breadth-first pattern matches the hypothesized text-transfer model of eye movement.

Another typical participant's gaze plot is shown in Figure 3. The general pattern is similar to the above. However, the participant adopted a depth-first pattern, instead of the above-mentioned breath-first pattern. Further analysis on other participants' gaze plots of the two top-down-layout concept maps reveals similar conclusions. Although no prior training on concept maps, these novices could generally adjust their eye movements quickly and employ the breath-first or depth-first text-transfer model to traverse the top-down-layout concept maps.

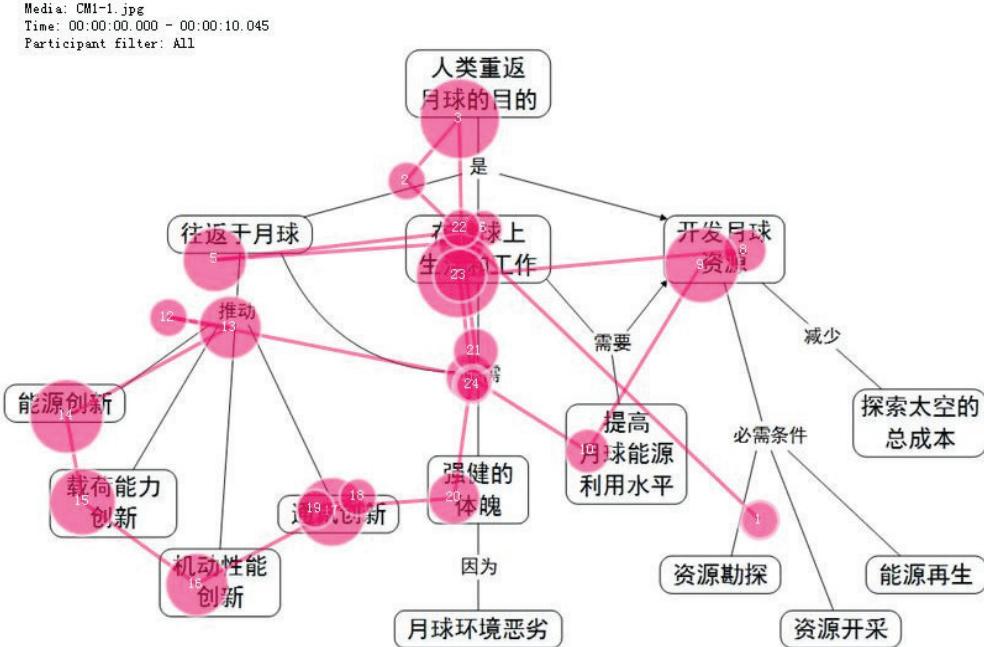


Figure 2: A typical gaze plot of the top-down-layout concept map 1.

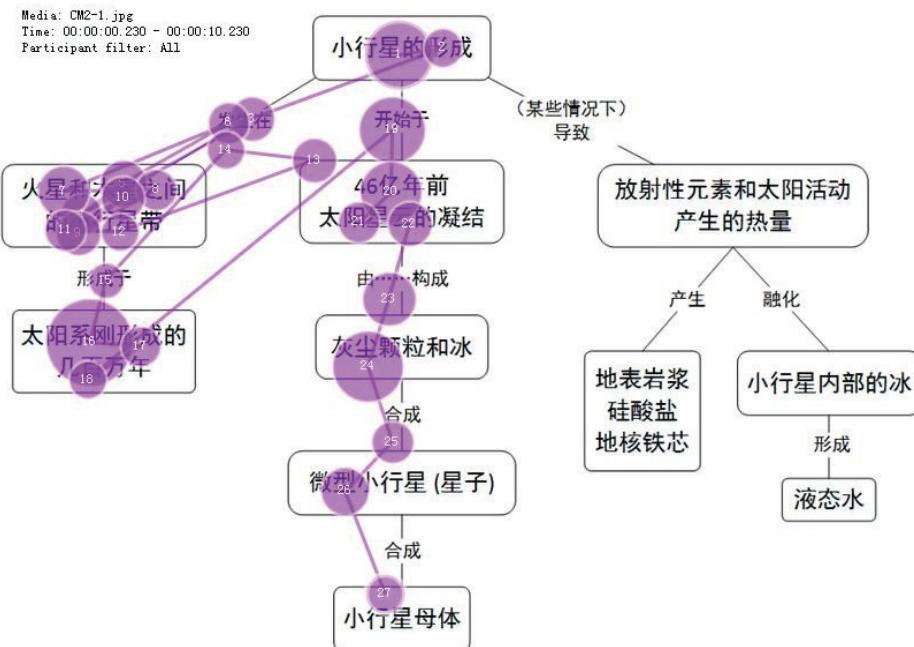


Figure 3: A typical gaze plot of the top-down layout concept map 2.

For the radial-layout concept map, the first fixation of participants generally falls into the upper-left of the map. It needs some time for participants to find the hub of the map. The general reading pattern still follows the top-down, left-right text-transfer model. Such finding mismatches with the hypothesized hub-first model of eye movement. The typical participants' eye gaze movements in the first 10 seconds on the radial-layout concept map 1 and 2 are shown in Figure 4 and 5.

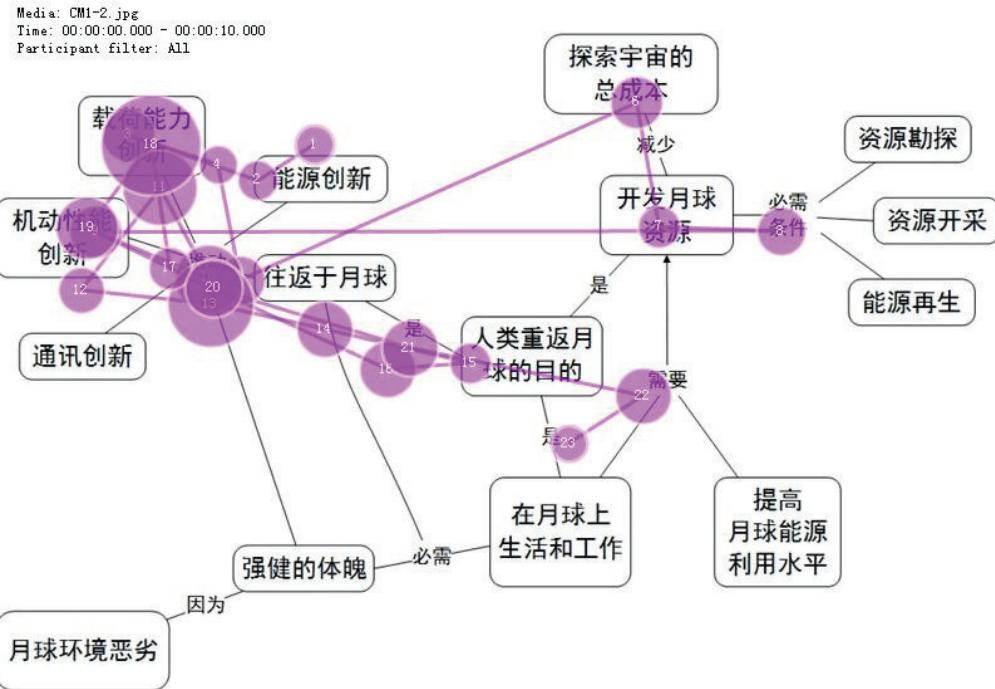


Figure 4: A typical gaze plot of the radial layout concept map 1.

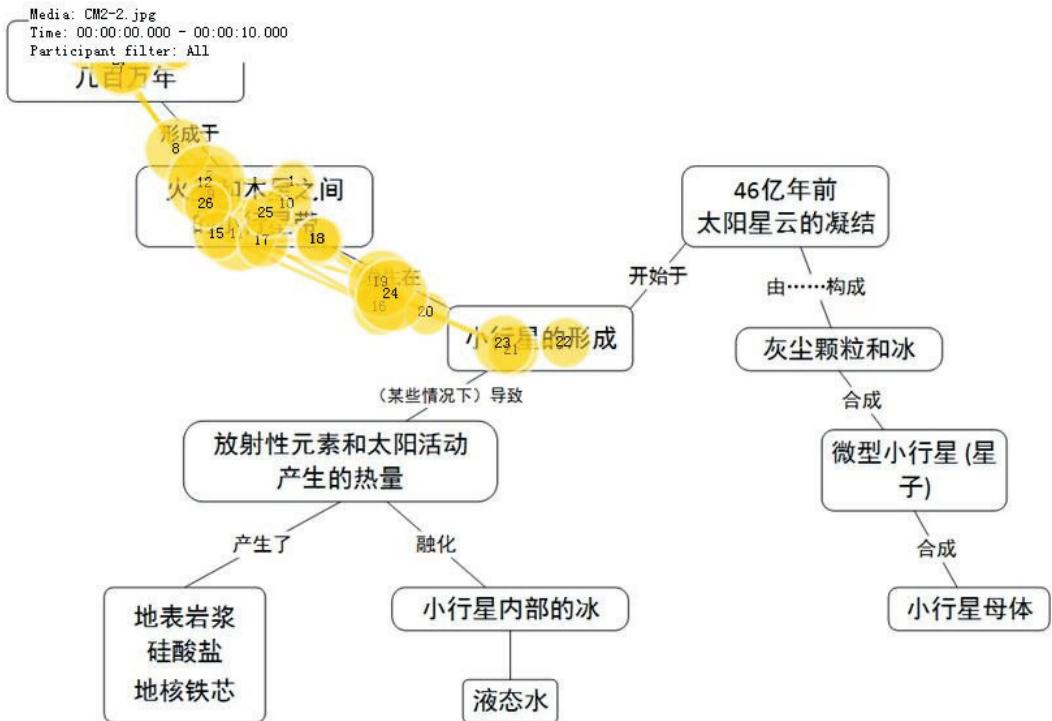


Figure 5: A typical gaze plot of the radial layout concept map 2.

Accordingly, we can conclude that the top-down layout can provide stronger cues, compared with radial layout, to guide the eye movement of a concept map novice. It may partially attribute to the education background of Chinese university students. They may not experience concept maps but they generally read tree diagrams in their past study.

4.2 Fixation heat map

Another output of the eye-tracking data is a representation of the areas of the screen receiving either more fixations or receiving the longest dwell times in a color-coded "hotspot" image of a concept map (see Figure 6 and 7). Specifically, the closer to red, the more fixations occur in an area of a concept map. Inspection of these heat maps reveals that on average the center of concept maps received the most fixations, and the bottom-right of concept maps received the least. In addition, people tended to pay more attention on nodes than linking phrases.



Figure 6. Fixation heat maps of top-down layout concept maps.

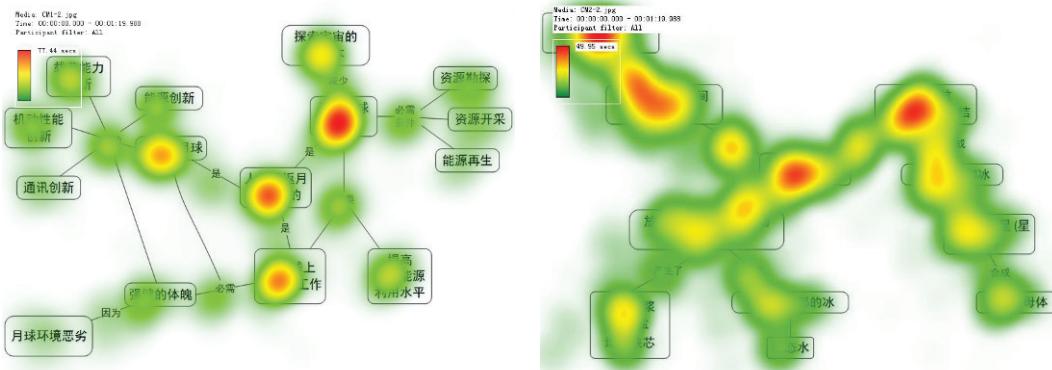


Figure 7. Fixation heat maps of radial layout concept maps.

Such findings are consistent with prior eye-tracking research on concept map (e.g., Nesbit et al., 2007). It indicates that the visual attention of nodes and links are not evenly distributed across the whole map. Concept map educators are suggested to consider the above issues when designing a good concept map.

5 Conclusions and Future Work

With the fast development of cognitive technologies, the education research begins to shift from behavioral perspective to cognitive perspective. In this study, we made an initial attempt to explore the eye movement patterns of concept map novices in the context of Chinese tertiary students. Results show that the top-down left-right pattern (i.e., text-transfer model) is dominated for Chinese tertiary students, no matter the layout of a concept map is top-down or radial. Results also show that visual attention of nodes and linking phrases are not evenly distributed, and center and upper-left region of a concept map receives more fixations.

We admit that the above conclusions are based on qualitative analysis of gaze plots and heat maps. In the future, we have planned to make quantitative analysis on the eye movement measures to support our arguments. Event though, we believe the conclusions of this study can disclose the eye movement patterns of concept map novices, and generate practical guidelines for concept maps design and learning to improve current instructional systems. The study also entails several interesting research directions. Our results show that concept map novices spent more time looking at concept nodes than linking phrases. It is of great interest to investigate the reasons at cognitive and neurological levels. Another promising direction is to identify the effects of individual differences (e.g., age and ethnicity) on eye movement patterns of concept map novices.

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